International Journal of Business and Economics
Vol. 8, No. 2, 2023, pp. 89-106

https://ielas.org/ijbe/index.php/ijbe
ISSN (online) 2545-4137

CLIMATE CHANGE RISK DISCLOSURE AND ACCOUNTING CHOICE: EVIDENCE FROM U.S. OIL AND GAS COMPANIES

Joanna (Jingwen) Zhao*, Ph.D., CMA
Department of Accounting. College of Business and Economics
California State University, Los Angeles
Los Angeles, CA 90032
E-mail: jzhao@calstatela.edu

Xinruo Wang, Ph.D.
Department of Accounting and Finance. College of Business
University of Wisconsin-Eau Claire
Eau Claire, WI 54701
E-mail: wangxinr@uwec.edu

David C. Yang, Ph.D., CMA, CFM
School of Accountancy. Shidler College of Business
University of Hawaii at Manoa
Honolulu, HI 96822
E-mail: yangd@hawaii.edu

*Corresponding Author: jzhao@calstatela.edu

Received: 2023-06-15 Accepted: 2023-08-25 Published online: 2023-09-18

Abstract

Focusing on U.S. oil and gas companies following the SEC's investigation of ExxonMobil's climate risk issues, this study investigates the impact of climate change risk (CCR) disclosure on corporate accounting choices. After examining U.S. oil and gas firms' 10-K filings, carbon disclosure project (CDP) reports, and multi-source corporate sustainability reports, we find a positive association between CCR disclosure and the full cost (FC) accounting choice, designating that oil and gas firms with greater CCR disclosures are more likely to adopt the FC method to record oil and gas exploration activities. Our study responds to the SEC's2010 and 2022 Climate Change Disclosure Guidance and encourages more oil and gas companies to disclose CCR and its impact on financial reporting to facilitate transparent transitions towards a low-carbon economy.

Keywords: climate change disclosure, carbon accounting, accounting choice, ESG, corporate sustainability, voluntary disclosure.

1. INTRODUCTION

In September 2016, the United States Securities and Exchange Commission (SEC) launched an investigation into *ExxonMobil* and its auditor *PricewaterhouseCoopers*, questioning how the country's largest oil group reported the value of its assets and disclosed the impact of climate change on its business (Olson and Viswanatha, 2016).

In 2018, the investigation was terminated due to insufficient evidence (Michaels and Olson, 2018). However, the SEC's scrutiny of the oil giant ExxonMobil instigated an uproar in the U.S. oil and gas industry. Since it is difficult for investors to determine which companies are taking action against climate change, investors are urgently requesting oil and gas companies to disclose the impact of CCR on business operations and corporate reporting (Diaz-Rainey *et al*., 2023; Matsumura *et al*., 2014; Pankratz *et al*., 2023; van Benthem *et al*., 2022).

As an exploration of U.S. oil and gas firms' CCR disclosure following the SEC's investigation of ExxonMobil, this study investigates how CCR disclosure affects oil and gas companies' procedural accounting choices. We delve into one of the most critical ESG (Environmental, Social, and Governance) risks confronting the sustainability of society–climate change (e.g., Borghei, 2021; SEC, 2022; TCFD, 2018). With the aim of preventing global temperatures from rising by 2°C above the pre-industrial level, nearly 200 countries signed the "Paris Agreement" in 2015, agreeing to reduce greenhouse gas emissions and encourage the transition to a low-carbon economy. The U.S. SEC released the Climate Change Disclosure Guidance in 2010 and proposed new rules to standardize climate-related disclosures in 2022 (SEC, 2022). The CDP, the Global Reporting Initiative (GRI), the Intergovernmental Panel on Climate Change (IPCC), and various other institutions are also striving to increase corporate awareness and improve disclosure guidelines regarding CCR matters.

Meanwhile, oil and gas companies are suffering from global warming and extreme weather, and they can choose the successful-efforts (SE) method or the full-cost (FC) method to record oil and gas exploration and development (E&D) activities. This crucial accounting choice affects how companies report their net income and cash flows and delineate E&D costs and assets across exploration, development, and production categories (Begley, 1990; Bryant, 2003). Since procedural accounting methods play a pivotal role in shaping reported costs, revenues, expenses, profits, and balance sheet valuations (Bryant, 2003; Lilien and Pastena, 1982; Misund *et al*., 2008), it is imperative to investigate the flexibility of procedural accounting choice under the influence of CCR disclosure, helping investors and other stakeholders better understand oil and gas firms' CCR disclosure and the E&D accounting choice that affect corporate earnings and cash flows (Diaz-Rainey *et al*., 2023; van Benthem *et al*., 2022).

To test our research question, after the SEC terminated the CCR investigation of ExxonMobil in 2018, we manually collected and investigated all U.S. oil and gas companies' 10-K financial reports, CDP reports, and corporate sustainability reports to examine whether these companies mentioned CCR issues and their E&D accounting choices.CCR disclosure information was collected from various sources, including the SEC's Edgar database, CDP database, Ceres database, GRI database, and companies' sustainability websites. Other financial indicators regarding accounting choice were collected from the Compustat and CRSP databases.

Our study makes important contributions to the previous literature. First, this study contributes to the previous research regarding corporate CCR disclosure and accounting choice topics. Although scholars have begun to study carbon disclosure and its corporate financial impact (e.g., Borghei, 2021; Downar *et al*., 2021; Matsumura *et al*., 2014; Tang and Demeritt, 2018; Wang, 2023), our study fills the gap between the CCR disclosure and E&D accounting choices by oil and gas firms, following the 2018 SEC's climate disclosure investigation of ExxonMobil. We manually collected companies' CCR disclosures from multiple sources and updated CCR disclosure research data with richer dimensions, providing a new influencing factor for oil and gas firms' procedural accounting choice (Begley, 1990; Bryant, 2003; Lilien and Pastena, 1982; Misund *et al*., 2008).

Further, our study enriches corporate financial reporting guidance for investors in the oil and gas industry, helping eliminate opacity in the disclosure practices of oil and gas companies facing severe CCRs (e.g., Lemma *et al*., 2020; Luo and Wu, 2019; Velte, 2021). Our study offers investors and other stakeholders a better understanding of the association between oil and gas CCR disclosure and accounting choices, supplying the public with effectual guidance to reveal the impact of CCR disclosure on the reporting trends of oil and gas companies' earnings and cash flows. Additionally, this study provides evidence for SEC, FASB, and government regulators by digging into the association between CCR disclosure and accounting choice in the energy sector. Following the release of the SEC's Climate Change Disclosure Guidance (SEC, 2010, 2022), this study responds to the urgent call from the SEC and global environmental organizations to encourage more oil and gas companies to disclose CCR to facilitate the transition towards a low-carbon economy (COP 27, 2022).

The remainder of this study is organized as follows. Section 2 provides the theoretical framework and Section 3 presents background information and hypothesis development. Sample selection and research design are discussed in Section 4. Section 5 presents and discusses our empirical results. Section 6 shows additional robustness test results, and Section 7 concludes the paper and highlights future research directions.

2. THEORETICAL FRAMEWORK

Agency theory states that when an economic entity (principal) has an agency relationship, another entity (agent) is authorized to make decisions on behalf of the principal (Subramaniam, 2006). Generally, agents have an information advantage over principals because agents are more directly involved in day-to-day business operations. Considering the information asymmetry between shareholders (principals) and managers (agents) in a shareholder-manager relationship, oil and gas companies' CCR disclosure can increase information transparency and shareholders' oversight, thereby reducing potential costs of conflicts (Benston, 1982; Broadstock *et al*., 2018; Lemma *et*

al., 2021; Prado-Lorenzo and Garcia-Sanchez, 2010). Thus, shareholders can reduce investment risks by understanding oil and gas firms' CCR disclosure and accounting choice strategies (Eleftheriadis and Anagnostopoulou, 2015; Griffin *et al*., 2017; Krishnamurti and Velayutham, 2018).

Debt covenant theory indicates that firms negotiate financial contracts with bondholders (Leftwich, 1981; Smith and Warner, 1979). These contracts have certain restrictions that affect the firms' financial investment, production policies, bond dividends, asset disposal and maintenance, and merger activities (Begley, 1990; Dyreng *et al*., 2022; Smith and Warner, 1979). Debt covenants help control the conflicts of interest between bondholders and shareholders. Once the firm comes close to breaching the contract, the debt contract will limit the firm's ability to pay dividends while adding additional agency costs and non-compliance costs (Dichev and Skinner, 2002). Managers' different accounting choices have different impacts on shareholders' interests and corporate wealth distribution. Managers have economic incentives to choose accounting methods more conducive to the firm to reduce the non-compliance costs from potential contract breach risks (Begley, 1990; Pittman and Zhao, 2020; Robin *et al*., 2017).

According to the debt covenant theory, since intense CCR increases the difficulty of oil and gas firms' mining and exploration activities, huge exploration costs and dry well costs make these high-risk companies more likely to face contractual default risks. As a result, oil and gas company managers have incentives to reduce default risks and mitigate institutional constraints through accounting choices (Collins *et al*., 1981; Gilje *et al*., 2020; Franz *et al*., 2014). Choosing the FC method to capitalize oil and gas exploration expenses can help maximize corporate income and smooth financial volatility, ensuring that oil and gas companies are not exposed to default risks and restrictions imposed by bondholders in their financial contracts (Beatty *et al*., 2002; Begley, 1990; Daley and Vigeland, 1983; Dyreng *et al*., 2022).

3. BACKGROUND AND HYPOTHESIS DEVELOPMENT

Accounting choices for oil and gas companies have been controversial since the 1970s (Bryant, 2003). Under U.S. GAAP, oil and gas companies can choose either the SE or the FC accounting method to describe E&D activities. The main difference between the two accounting methods, SE and FC, is how they calculate exploration costs and oil and gas asset impairments. Under the SE method, only exploration costs associated with successful wells are recorded as assets. All exploration costs for unsuccessful or dry wells are included in expenses. Companies using the SE method apply the guidelines from FASB ASC Topic 932 (Extractive Activities - Oil and Gas) and Topic 360 (Property, Plant, and Equipment) to explain the impairment of their oil and gas assets.

In contrast, the FC approach allows exploration companies to capitalize all costs associated with exploration activities for oil and gas reserves, regardless of the success of efforts. While the FC approach allows unsuccessful exploration costs to be capitalized and incorporated into oil and gas assets, the SEC imposed an upper limit on the total costs that FC companies can capitalize, known as the "ceiling test." Oil and gas firms using the FC method should apply the guidelines in SEC Regulation S-X Rules 4-10, SAB (Staff Accounting Bulletin) Subject 12.D, and FRC (Financial Reporting Codification) Section 406.01.c.

Managers have different incentives to choose particular accounting methods (Fields *et al*., 2001; Libby *et al*., 2015; Wells, 2020; Zhang and Zhang, 2023). Lilien and Pastena (1982) mention that management's accounting choices can result indifferent cumulative earnings based on firms' specific circumstances and the SEC's procedural standards. Compared with the FC method, the SE method leads to more conservative accounting results for total assets and income on average. Selecting the SE method accelerates the recording of oil and gas costs, and the rapid spending on these costs reduces reported income (Bryant, 2003; Misund *et al*., 2008). Hence, companies adopting the SE method are classified as income minimizers, while companies choosing the FC method are classified as income maximizers (Foster, 1980; Lilien and Pastena, 1982).

Lilien and Pastena (1982) point out that oil and gas extraction risks affect firms' choices of oil and gas methods. Companies facing higher oil extraction and detection risks are more inclined to choose the FC accounting method to smooth operating income. According to the IPCC Assessment Reports, global warming increases the frequency and magnitude of extreme weather events. Severe weather risks challenge oil and gas exploration and production facilities (IPCC, 2023). The IPCC states that CCR brings multiple physical hazards to traditional oil and gas exploration equipment and pipeline transportation. Severe waves and storm surges also challenge deepwater floating systems and the production facilities on offshore oil platforms. Due to the adverse weather impact and the challenges brought by sea ice, subsea facilities can no longer enter some deep sea areas to exploit resources, and the drilling operations on offshore platforms have been forced to stop (IPCC, 2014, 2023; Masnadi and Brandt, 2017). At the same time, onshore oil extraction facilities are suffering from permafrost instability and accelerated flooding from severe climate risks. Due to the extreme climate crisis on land and sea, actively exploring oil and gas companies tend to detect a higher proportion of dry wells, increasing early exploration failures and higher mining costs. To overcome these physical challenges, offshore and onshore oil drilling facilities and oil production investments can be exceptionally expensive (Erickson *et al*., 2018; Kang *et al*., 2020; Maxwell, 1997).

As exploratory risks and drilling costs increase, oil and gas companies choosing the SE method accelerate the recording of dry well costs and exploration expenses, which

will damage corporate income and account balances (Lilien and Pastena, 1982; Misund *et al*., 2008). According to the debt covenant theory, oil and gas companies under global warming and extreme CCR will likely face contract default risks due to increased oil exploration costs. Contract default risks will limit corporate financial capability and production activities (Bhaskar *et al*., 2017; Pittman and Zhao, 2020; Robin *et al*., 2017). High exploration costs will pressure oil and gas companies as they may face higher debts and institutional investment constraints. Oil and gas companies with higher levels of CCR disclosure are more likely to realize the exploration risks posed by CCR and thus have an incentive to mitigate the debt covenant restrictions imposed by bondholders through internal accounting choices. Managers are willing to adopt looser accounting policies, such as the FC method that maximizes earnings, to help the firm reduce default risk costs and ease corporate financial constraints (Begley, 1990; Dyreng *et al*., 2022; Guttman and Marinovic, 2018). Furthermore, corporations consider CCR disclosure and income maximization as positive signs to reduce agency costs and help investors evaluate firms' ability to cope with CCR, thereby enhancing the potential market value of companies (Borghei, 2021; Brooks and Oikonomou, 2018; Eleftheriadis and Anagnostopoulou, 2015; Griffin *et al*., 2017; Matsumura *et al*., 2014). Therefore, based on the above discussion, our hypothesis is illustrated as follows:

H1: *Climate change risk disclosure is positively associated with the full-cost (FC) accounting method that maximizes income.*

4. SAMPLE SELECTION AND RESEARCH DESIGN

4.1 Sample Collection

Our research investigates U.S. oil and gas companies' CCR disclosure and assesses the impact of CCR disclosure on corporate E&D accounting choice. In 2016, the SEC investigated ExxonMobil for misleading investors about the CCR issue and its implications (Olson and Viswanatha, 2016). After the SEC dropped this investigation in 2018, we manually collected the CCR disclosure of all U.S. oil and gas companies for fiscal years 2014 through 2017 and observed the impact of these disclosures on firms' accounting choices.

To test our research questions, we collected all U.S. oil and gas companies for the selected years.Table 1 presents the sample selection criteria.After searching the oil and gas industry SIC code (2-digit SIC code 13) from the Compustat North America database, we collected 1034 annual observations of U.S. oil and gas companies from 315 unique companies.We first ruled out bankrupt or start-up companies and their sample observations. This brought our total sample to 804 complete annual company observations, representing 201 unique U.S. oil and gas companies for the year range.

Other observation samples we excludedwere either due to the lack of 10-K annual reports in the Edgar database or the unavailability of financial variable data needed for

the empirical model in the Compustat database. Next, as shown in Table 1, the complete sample for testing Hypothesis 1 includes 479 firm-year observations from 129 unique oil and gas companies.

Table 1

Sample Selection

Panel: Sample Selection		
	Firm-year	***Unique firms***
U.S. Oil and Gas Companies available in Compustat database (SIC code: two-digit 13)	1,034	315
Less: Bankrupt and Start-up firm observations	(230)	(114)
U.S. Oil and Gas Companies available from the 2014 - 2017 fiscal year	**804**	**201**
Less:		
Number of observations with missing 10-K data	(43)	(3)
Number of observations with missing Compustat data	(282)	(69)
Final sample for H1 test	**479**	**129**

Regarding the measurement of CCR disclosure, we manually collected all U.S. oil and gas companies' CCR-related disclosures from 10-K financial reports, CDP reports, corporate websites, and corporate sustainability reports. We searched for CCR-related content through multiple channels and compared these voluntary disclosures to understand the major risks and subsequentimpactsbrought by climate change. We first collected the financial reports of sample companies from the SEC's Edgar database and then collected the companies' CDP climate disclosure reports from the CDP database. Additionally, we collected corporate sustainability reports through the company websitesand the GRI's Sustainability Disclosure Database (discontinued in 2020). All other financial indicators of the sample companies were collected from Compustat and CRSP databases.

4.2 Research Design

Our hypothesis investigates the association between U.S. oil and gas firms' CCR disclosure and the accounting choice of adopting the SE or FC method, which either minimizes or maximizes income. The CCR disclosure proxy has been added to the accounting choice model according to Deakin (1979) and Lilien and Pastena (1982) as follows:

$$AC_t = \beta_0 + \beta_1 CCRD_t + \beta_2 REV_t + \beta_3 AGE_t + \beta_4 EXPR_t + \beta_5 LEV_t$$

$$+ Year\ Fixed\ Effect + \varepsilon_t$$

where AC_t is coded as 0 if the firm chooses the SE method and 1 if the firm chooses the FC method in year t. We examine the impact of CCR disclosure on accounting choice and use the $CCRD_t$ variable to measure the firm's CCR disclosure in 10-K annual reports, CDP reports, and corporate sustainability reports. For the remaining variables,

REV_t is the firm's revenue in year t to control firm size, according to Lilien and Pastena (1982). AGE_t measures the firm's age as the consistency variable. $EXPR_t$ is calculated as oil and gas exploration expenditures divided by oil and gas operating income. We use $EXPR_t$ to test the exploratory risk of U.S. oil and gas firms. LEV_t is the leverage variable, calculated as the firm's debt divided by shareholders' equity in year t, as shown below in Lilien and Pastena (1982).

Lilien and Pastena (1982) predict whether firms choose accounting methods that maximize or minimize income, and the general model is as follows:

$$Z_i = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

where Z_i = 1 if the company minimized cumulative income,
0 if the company maximized cumulative income,
and X_1 = Revenue (political variable), X_2 =Age (consistency variable), X_3 = Exploratory risk, X_4= Debt/Shareholders' equity (leverage).

5. EMPIRICAL RESULTS

5.1 Descriptive Statistics

Table 2 presents descriptive statistics. All continuous variables in the tests were winsorized at the 1% level at two tails of the distribution to remove the noise from outliers. Panel A of Table 2 shows summary statistics for the full sample of U.S. oil and gas companies from 2014 to 2017. Panel A indicates that most sample companies have chosen at least one CCR disclosure channel from the firm's 10-K annual disclosure, CDP report, or corporate sustainability report. In addition, the average value of REV_t is much larger than the median, designating that in the sample of U.S. oil and gas firms, some large companies with high revenue increase the mean value of the REV_t variable.

Table 2

Descriptive Statistics

Panel A: Full Sample[a]					
	Mean	**p25**	**Median**	**p75**	**Std. Dev.**
AC_t	0.038	0.000	0.000	0.000	0.190
$CCRD_t$	1.213	1.000	1.000	1.000	0.670
REV_t	3.621	0.022	0.266	1.244	16.285
AGE_t	19.643	7.000	13.000	27.000	16.547
$EXPR_t$	0.712	-1.164	-0.212	1.641	11.375
LEV_t	0.530	0.212	0.407	0.679	1.085

[a] Table 2 provides descriptive statistics for sample observations. Panel A of Table 2 shows summary statistics for the full sample of U.S. oil and gas companies from fiscal years 2014 to 2017.Panel B of Table 2 partitions the sample observations into oil and gas firms with CCR disclosure (*CCRD* group) and without CCR disclosure (*non-CCRD* group) in the four-year range.

Panel B: Sample Breakdown of CCR Disclosure for U.S. Oil and Gas Firms					
	CCRD			***Non-CCRD***	
	(n=454)			*(n=25)*	
	Mean	**Median**		**Mean**	**Median**
AC_t	0.031***[b]	0.000###[c]		0.160	0.000
$CCRD_t$	1.280***	1.000###		0.000	0.000
REV_t	3.820	0.298###		0.003	0.0001
AGE_t	19.700	13.000		18.600	14.000
$EXPR_t$	0.771	-0.217		-0.357	-0.137
LEV_t	0.532	0.421###		0.498	0.000

[b] ***, **, * indicate significance at < .01, < .05, and < .10 levels, respectively, for two-tailed t-tests of difference in means.
[c] ###, ##, # indicate significance at < .01, < .05, and < .10 levels, respectively, for two-tailed Wilcoxon tests of difference in medians.
All variables are defined in Appendix A.

Panel B of Table 2 divides sample observations into oil and gas firms with CCR disclosure (CCRD group) and oil and gas firms without CCR disclosure (non-CCRD group) in the four-year range. According to this panel, we find that the average REV_t of the CCRD group is significantly higher than that of the non-CCRD group, denoting that high-revenue oil firms are more inclined to disclose climate risks compared with low-revenue oil firms. Table 3 provides the correlation coefficients for all tested variables in the main hypothesis model. Because the variables in the empirical model include continuous and indicator variables, Pearson's and Spearman's rank correlations are shown below and above the diagonal in Table 3.

Table 3

Correlation Coefficients

Panel: Pearson / Spearman Correlation Matrix of the Main Model[a]						
	AC_t	*CCRD*	REV_t	AGE_t	$EXPR_t$	LEV_t
AC_t		-0.0360	**-0.0894**	**-0.1295**	0.0538	0.0242
CCRD	0.0027		**0.6555**	**0.3353**	0.0242	0.0706
REV_t	-0.0370	**0.4841**		**0.3776**	0.0209	**0.2134**
AGE_t	**-0.1232**	**0.4525**	**0.4534**		-0.0260	-0.0153
$EXPR_t$	**0.0783**	-0.0049	0.0118	-0.0197		-0.0190
LEV_t	0.0226	-0.0283	-0.0450	0.0133	0.0259	

[a] Table 3 presents the Pearson (Spearman) correlation matrix of Equation (1) below (above) the diagonal. Correlations in bold are statistically significant at the 0.10 level. Coefficients in plain text are not significant (p > 0.10). All variables are defined in Appendix A.

5.2 Test Results

The empirical results of the hypothesis are shown in Table 4. Since some oil and gas companies did not disclose which oil and gas method was selected in their financial report footnotes, the complete sample has been reduced to 479 firm-year observations. According to the Lilien and Pastena (1982) model, our model uses probit regressions incorporating CCR disclosures and four influencing factors (REV_t, AGE_t, $EXPR_t$, and LEV_t)

to examine the effect on oil and gas accounting choices. From the results in Table 4, the coefficient of $CCRD_t$ is positive and significant (0.533, $p< 0.05$), which indicates that oil and gas firms with more CCR disclosure are more likely to choose the FC method to record oil and gas exploration. According to the assumptions in Section 3, the difficulty and costs of oil and gas exploration activities have increased dramatically due to global warming and natural risks. The direct impact of CCR on oil and gas drilling and exploration activities encourages companies to adopt loose accounting policies and the FC method to minimize financial volatility and smooth earnings. Stakeholder pressure based on the debt covenant theory also motivates oil and gas companies to choose the FC method to ease institutional constraints and maximize cumulative income simultaneously.

Table 4

Probit Regression Analysis: Effects of CCR Disclosure on E&D

Accounting Choice

Variables	Predict Signs	Coefficients	Z-value
$CCRD_t$	**+**	***0.533****	***2.09***
REV_t	**-**	-0.120	-0.82
AGE_t	**-**	-0.043**	-2.41
$EXPR_t$	**+**	0.012*	1.47
LEV_t	**+**	0.102	0.92
Intercept	**?**	-1.731	-0.74
Year effect	Yes		
# of observations	479		
Pseudo R^2	0.1226		

Table 4presents the empirical results of Equation (1) using probit regressions to examine the effect of U.S. oil and gas firms' CCR disclosure on corporate E&D accounting choice.
Our sample includes 479 firm-year observations from fiscal years 2014 to 2017.
***, **, * represent statistical significance at 1%, 5% and 10% levels, respectively. Coefficients on year dummies are not reported for parsimony.
All variable definitions are provided in Appendix A.

For the remaining four variables, the coefficient of REV_t is negative (-0.120), meaning that companies with higher revenue are more inclined to choose the SE method to record oil and gas exploration activities. Large oil and gas companies would avoid using income maximization methods because these companies may become political targets alongside industry giants (Bowen *et al*., 1981; Watts and Zimmerman, 1978). However; this result is not significant at the conventional level. In addition, the AGE_t coefficient is negative and significant (-0.043, $p< 0.05$), denoting that older companies are more willing to choose the SE method. In fact, the SE method was the only option for old companies in the oil and gas industry until the late 1950s. Since transferring from the SE to the FC method involves varying levels of bookkeeping and other costs, some old oil and gas companies continued to use the SE method.

In contrast, the coefficient for exploration risk $EXPR_t$ is significantly positive (0.012, $p<$ 0.10), illustrating that firms with higher exploration densities prefer the FC approach. Lilien and Pastena (1982) mention that the more aggressively oil and gas companies explore, the higher the probability of finding dry wells. These failure costs will increase significantly in the early stages of drilling activities. By adopting the FC approach, oil and gas firms experiencing high exploration risks can minimize corporate financial volatility. The coefficient significance of exploration risk is lower than the previous variables ($CCRD_t$ and AGE_t) at the 0.10 level. The firm's LEV_t coefficient is positive (0.102), designating that oil and gas firms with higher leverage would face higher contract default risks. Therefore, managers have incentives to choose the FC method to maximize profits and ease financial burden.

6. ROBUSTNESS TEST

In the main model above, we applied the accounting choices of oil and gas companies as our dependent variable. Following Lilien and Pastena (1982), we collect oil and gas firms' dual accounting choices as the new dependent variable in the robustness test, including oil and gas accounting choices and adjustments to retained earnings. If the two accounting choices affect corporate income in the same direction, these samples are defined as dual choice maximization or dual choice minimization. The dual-choice maximization samples (labeled as 1) refer to firms that use the FC method and make negative adjustments to retained earnings. Conversely, the dual-choice minimization samples (labeled as 0) are firms that use the SE method and record zero or positive adjustments to retained earnings. Table 5 demonstrates the robustness test results of the oil and gas accounting choice model for Hypothesis 1. The coefficients are broadly consistent with our original predictions; only the leverage variable is in the opposite direction to previous findings. The coefficient of $CCRD_t$ in this dual-choice model remains positive and significant (1.798, $p<$ 0.01), showing that the more CCR disclosures oil and gas firms prepare, the more likely firm managers are to choose income-maximizing accounting strategies. Since the dual accounting model considers both selection methods, the Pseudo R^2 in this model has been improved, which better explains the relationship between oil and gas firms' CCR disclosure and accounting choice.

Table 5

Probit Regression Analysis: Effects of CCR Disclosure on Dual Accounting Choice with Adjustment to Retain Earnings

Variables	Predict Signs	Coefficients	Z-value
$CCRD_t$	**+**	***1.798****	***3.66***
REV_t	**-**	-0.312	-1.00
AGE_t	**-**	-0.021	-0.81
$EXPR_t$	**+**	0.024**	2.33
LEV_t	**+**	-0.036	-0.14
Intercept	**?**	-3.703	-5.83
Year effect	Yes		
# of observations	360		
Pseudo R^2	0.3891		

Table 5 demonstrates the robustness test results of the oil and gas accounting choice model. Following Lilien and Pastena (1982), we collect U.S. oil and gas firms' dual accounting choices as the new dependent variable, including oil and gas accounting methods and adjustments to retained earnings.
The dual-choice maximization indicator (equal to 1) refers to firms that use the FC method and make negative adjustments to retained earnings. Conversely, the dual-choice minimization indicator (equal to 0) refers to firms that use the SE method and record zero or positive adjustments to retained earnings.
***, **, * represents statistical significance at the 1%, 5% and 10% levels, respectively. Coefficients on year dummies are not reported for parsimony.

All variable definitions are provided in Appendix A.

7. CONCLUSION

With the increasing frequency and intensity of extreme weather and natural disasters, climate change poses a continuing and significant threat to the energy industry represented by oil and gas companies (Ceres, 2023; COP 27, 2022; TCFD, 2022). Numerous stakeholders have called on oil and gas companies to disclose CCRs that affect operations and credible steps to address them (Broadstock *et al*., 2018; Clarkson *et al*., 2008; Griffin *et al*., 2017; Liesen *et al*., 2015). Taking the SEC's investigation of ExxonMobil as a starting point, our study expands the research scope to include all U.S. oil and gas companies, delving into CCR disclosure and its impact on corporate accounting choices in the oil and gas industry.

Our findings show a significant positive correlation between CCR disclosure and the FC accounting choice of U.S. oil and gas companies, suggesting that oil and gas firms with more CCR disclosure are more inclined to choose the FC method to record oil and gas exploration activities. By preparing CCR disclosure, oil and gas firms demonstrate their awareness of CCRs and the attendant rise in exploratory and drilling risks. Such disclosures highlight firms' actions and contributions to mitigate CCR, such as managing carbon emissions and developing renewable clean energy. Our results denote that these corporations tend to adopt the FC method that maximizes earnings to show investors their ability to cope with increasing CCR and consequent costs in response to public

concerns. This accounting practice also helps ease the financial constraints of business and reduces potential default risks. With the development and implementation of CCR disclosure guidelines and regulations, we look forward to the broader use of CCR reports to assess the potential disclosure impact on firm-level and industry-level operations.

Our study contributes at both academic and practical levels. From an academic perspective, our study points out a new direction for research on corporate CCR disclosure and its financial reporting impact (e.g., Downar *et al*., 2021; Lemma *et al*., 2020; Matsumura *et al*., 2014; Tang and Demeritt, 2018; Wang, 2023) by investigating the relationship between CCR disclosure and accounting choices under increasing global warming risks. From a practical perspective, our research provides corporate valuation assistance for oil and gas industry investors facing severe CCRs and helps raise public awareness of CCR disclosure and emission reductions. A growing number of independent global organizations, encompassing GRI, IPCC, and TCFD, have begun drafting guidelines to aid companies and organizations in preparing and disclosing CCR reports. Responding to the domestic SEC Climate Disclosure Guidelines (SEC, 2010, 2022) and the international organizations' call for CCR disclosure, our study encourages U.S. oil and gas companies to disclose CCR information and corporate valuation strategies to gain broader support from investors and society.

There are fruitful potential research directions related to CCR disclosure and corporate reporting strategies that can be expanded in the future. For now, our study is mainly focused on the oil and gas-based energy industry, and future research samples can be extended to other industries closely related to CCR issues, such as the five critical sectors most affected by CCRs, namely electricity, oil and gas, transportation, insurance, and agriculture (Ceres, 2023). Besides the U.S. oil and gas companies analyzed in this study, we hope to explore carbon disclosure practices in other countries and track global climate change reporting trends in the future. Additionally, potential research may scrutinize the relevance and impact of CCR disclosure on various financial aspects and unearth more exciting opportunities for accounting research on climate change and ESG issues.

REFERENCES

Beatty, A., Ramesh, K., & Weber, J. (2002). The importance of accounting changes in debt contracts: the cost of flexibility in covenant calculations. *Journal of Accounting and Economics*, *33*(2), 205-227. https://doi.org/10.1016/S0165-4101(02)00046-0

Begley, J. (1990). Debt covenants and accounting choice. *Journal of Accounting and Economics*, *12*(1-3), 125-139. https://doi.org/10.1016/0165-4101(90)90044-5

Benston, G.J. (1982). Accounting and corporate accountability. *Accounting, Organizations and Society*, *7*(2), 87-105. https://doi.org/10.1016/0361-3682(82)90014-9

Bhaskar, L.S., Krishnan, G.V., & Yu, W. (2017). Debt covenant violations, firm financial distress, and auditor actions. *Contemporary Accounting Research*, *34*(1), 186-215. https://doi.org/10.1111/1911-3846.12241

Borghei, Z. (2021). Carbon disclosure: A systematic literature review. *Accounting & Finance 61*(4), 5255-5280. https://doi.org/10.1111/acfi.12757

Bowen, R.M., Noreen, E.W., & Lacey, J.M. (1981). Determinants of the corporate decision to capitalize interest. *Journal of Accounting and Economics, 3*(2), 151-179. https://doi.org/10.1016/0165-4101(81)90011-2

Broadstock, D.C., Collins, A., Hunt, L.C., & Vergos, K. (2018). Voluntary disclosure, greenhouse gas emissions and business performance: Assessing the first decade of reporting. *The British Accounting Review, 50*(1), 48-59. https://doi.org/10.1016/j.bar.2017.02.002

Brooks, C., & Oikonomou, I. (2018). The effects of environmental, social and governance disclosures and performance on firm value: A review of the literature in accounting and finance. *The British Accounting Review*, *50*(1), 1-15. https://doi.org/10.1016/j.bar.2017.11.005

Bryant, L. (2003). Relative value relevance of the successful efforts and full cost accounting methods in the oil and gas industry. *Review of Accounting Studies*, *8*(1), 5-28. https://doi.org/10.1023/A:1022645521775

Ceres.(2023).Advancing Climate Solutions. Available at: https://www.ceres.org/climate

Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society, 33*(4-5), 303-327. https://doi.org/10.1016/j.aos.2007.05.003

Collins, D.W., Rozeff, M.S., & Dhaliwal, D.S. (1981). The economic determinants of the market reaction to proposed mandatory accounting changes in the oil and gas industry: A cross-sectional analysis. *Journal of Accounting and Economics*, *3*(1), 37-71. https://doi.org/10.1016/0165-4101(81)90034-3

COP 27, (2022). COP27: Delivering for people and the planet. Available at: https://www.un.org/en/climatechange/cop27

Daley, L.A., & Vigeland, R.L. (1983). The effects of debt covenants and political costs on the choice of accounting methods: The case of accounting for R&D costs. *Journal of Accounting and Economics*, *5*, 195-211. https://doi.org/10.1016/0165-4101(83)90012-5

Deakin III, E.B. (1979). An analysis of differences between non-major oil firms using successful efforts and full cost methods. *The Accounting Review*, 722-734. http://www.jstor.org/stable/245628

Diaz-Rainey, I., Griffin, P.A., Lont, D.H., Mateo-Márquez, A., & Zamora-Ramírez, C. (2023). Shareholder Activism on Climate Change: Evolution, Determinants, and Consequences. *Journal of Business Ethics, Forthcoming*. Available at SSRN: https://ssrn.com/abstract=4511019

Dichev, I.D., & Skinner, D.J. (2002).Large–sample evidence on the debt covenant hypothesis. *Journal of Accounting Research*, *40*(4), 1091-1123. https://doi.org/10.1111/1475-679X.00083

Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., & Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. *Review of Accounting Studies*, *26*, 1137-1175. https://doi.org/10.1007/s11142-021-09611-x

Dyreng, S.D., Hillegeist, S.A., & Penalva, F. (2022). Earnings management to avoid debt covenant violations and future performance. *European Accounting Review*, *31*(2), 311-343. https://doi.org/10.1080/09638180.2020.1826337

Eleftheriadis, I.M., Anagnostopoulou, E.G., (2015). Relationship between corporate climate change disclosures and firm factors. *Business Strategy and the Environment 24*, 780-789. https://doi.org/10.1002/bse.1845

Erickson, P., Lazarus, M., & Piggot, G. (2018). Limiting fossil fuel production as the next big step in climate policy. *Nature Climate Change*, *8*(12), 1037-1043. https://doi.org/10.1038/s41558-018-0337-0

Fields, T.D., Lys, T.Z., & Vincent, L. (2001). Empirical research on accounting choice. *Journal of Accounting and Economics*, *31*(1-3), 255-307. https://doi.org/10.1016/S0165-4101(01)00028-3

Foster, G. (1980). Accounting policy decisions and capital market research. *Journal of Accounting and Economics*, *2*(1), 29-62. https://doi.org/10.1016/0165-4101(80)90014-2

Franz, D.R., HassabElnaby, H.R., & Lobo, G.J. (2014). Impact of proximity to debt covenant violation on earnings management. *Review of Accounting Studies*, *19*, 473-505. https://doi.org/10.1007/s11142-013-9252-9

Gilje, E.P., Loutskina, E., & Murphy, D. (2020). Drilling and debt. *The Journal of Finance*, *75*(3), 1287-1325. https://doi.org/10.1111/jofi.12884

Griffin, P.A., Lont, D.H., & Sun, E.Y. (2017).The relevance to investors of greenhouse gas emission disclosures. *Contemporary Accounting Research*, 34(2), 1265-1297. https://doi.org/10.1111/1911-3846.12298

Guttman, I., & Marinovic, I. (2018). Debt contracts in the presence of performance manipulation. *Review of Accounting Studies*, *23*, 1005-1041. https://doi.org/10.1007/s11142-018-9450-6

Intergovernmental Panel on Climate Change (IPCC). (2014). Fifth assessment report (AR5). Available at: https://www.ipcc.ch/report/ar5

Intergovernmental Panel on Climate Change (IPCC). (2023). Sixth assessment report (AR6). Available at: https://www.ipcc.ch/report/ar6/syr/

Kang, J.N., Wei, Y.M., Liu, L.C., Han, R., Yu, B.Y., & Wang, J.W. (2020). Energy systems for climate change mitigation: A systematic review. *Applied Energy*, *263*, 114602. https://doi.org/10.1016/j.apenergy.2020.114602

Krishnamurti, C., & Velayutham, E. (2018).The influence of board committee structures on voluntary disclosure of greenhouse gas emissions: Australian evidence. *Pacific-Basin Finance Journal, 50*, 65-81. https://doi.org/10.1016/j.pacfin.2017.09.003

Leftwich, R. (1981). Evidence of the impact of mandatory changes in accounting principles on corporate loan agreements. *Journal of Accounting and Economics*, *3*(1), 3-36. https://doi.org/10.1016/S0165-4101(81)80001-8

Lemma, T.T., Lulseged, A., & Tavakolifar, M. (2021). Corporate commitment to climate change action, carbon risk exposure, and a firm's debt financing policy. *Business Strategy and the Environment*, *30*(8), 3919-3936. https://doi.org/10.1002/bse.2849

Lemma, T.T., Shabestari, M.A., Freedman, M., & Mlilo, M. (2020). Corporate carbon risk exposure, voluntary disclosure, and financial reporting quality. *Business Strategy and the Environment*, *29*(5), 2130-2143. https://doi.org/10.1002/bse.2499

Libby, R., Rennekamp, K.M., & Seybert, N. (2015). Regulation and the interdependent roles of managers, auditors, and directors in earnings management and accounting choice. *Accounting, Organizations and Society, 47*, 25-42. https://doi.org/10.1016/j.aos.2015.09.003

Liesen, A., Hoepner, A.G., Patten, D.M., & Figge, F. (2015). Does stakeholder pressure influence corporate GHG emissions reporting? Empirical evidence from Europe. *Accounting, Auditing & Accountability Journal 28*(7), 1047-1074. https://doi.org/10.1108/AAAJ-12-2013-1547

Lilien, S., & Pastena, V. (1982). Determinants of intramethod choice in the oil and gas industry. *Journal of Accounting and Economics*, *4*(3), 145-170. https://doi.org/10.1016/0165-4101(82)90007-6

Luo, L., & Wu, H. (2019). Voluntary carbon transparency: A substitute for or complement to financial transparency?. *Journal of International Accounting Research*, *18*(2), 65-88. https://doi.org/10.2308/jiar-52421

Masnadi, M.S., & Brandt, A.R. (2017). Climate impacts of oil extraction increase significantly with oilfield age. *Nature Climate Change*, *7*(8), 551. https://doi.org/10.1038/nclimate3347

Matsumura, E.M., Prakash, R., & Vera-Muñoz, S.C. (2014). Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review*, *89*(2), 695-724. https://doi.org/10.2308/accr-50629

Maxwell, B. (1997). Recent climate patterns in the Arctic. *Global Change and Arctic Terrestrial Ecosystems*, 21-46. Springer, New York, NY.

Michaels, D., & Olson, B. (2018). SEC drops probe of Exxon's climate-change disclosures. *Wall Street Journal*. Available at: https://www.wsj.com/articles/sec-drops-probe-of-exxons-climate-change-disclosures-1533317730

Misund, B., Asche, F., & Osmundsen, P. (2008). Industry upheaval and valuation: Empirical evidence from the international oil and gas industry. *The International Journal of Accounting*, *43*(4), 398-424. https://doi.org/10.1016/j.intacc.2008.09.007

Olson, B., & Viswanatha, A. (2016). SEC probes Exxon over accounting for climate change. *Wall Street Journal*. Available at: https://www.wsj.com/articles/sec-investigating-exxon-on-valuing-of-assets-accounting-practices-1474393593

Pankratz, N., Bauer, R., & Derwall, J. (2023). Climate change, firm performance, and investor surprises. *Management Science*. https://doi.org/10.1287/mnsc.2023.4685

Pittman, J., & Zhao, Y. (2020). Debt covenant restriction, financial misreporting, and auditor monitoring. *Contemporary Accounting Research*, *37*(4), 2145-2185. https://doi.org/10.1111/1911-3846.12579

Prado-Lorenzo, J.M., & Garcia-Sanchez, I.M. (2010). The role of the board of directors in disseminating relevant information on greenhouse gases.*Journal of Business Ethics, 97*(3), 391-424. https://doi.org/10.1007/s10551-010-0515-0

Robin, A., Wu, Q., & Zhang, H. (2017). Auditor quality and debt covenants. *Contemporary Accounting Research*, *34*(1), 154-185. https://doi.org/10.1111/1911-3846.12243

SEC. (2010). Commission Guidance Regarding Disclosure Related to Climate Change. Available at: https://www.sec.gov/rules/interp/2010/33-9106.pdf

SEC. (2022). SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors. Available at: https://www.sec.gov/news/press-release/2022-46

Smith Jr, C.W., & Warner, J.B. (1979). On financial contracting: An analysis of bond covenants. *Journal of Financial Economics*, *7*(2), 117-161. https://doi.org/10.1016/0304-405X(79)90011-4

Subramaniam, N. (2006). Agency theory and accounting research: an overview of some conceptual and empirical issues. *Methodological Issues in Accounting Research: Theories and Methods*, 55-81. Spiramus Press, London, England.

Tang, S., & Demeritt, D. (2018). Climate change and mandatory carbon reporting: Impacts on business process and performance. *Business Strategy and the Environment, 27*(4), 437-455. https://doi.org/10.1002/bse.1985

TCFD. (2018). Task Force on Climate-related Financial Disclosures: 2018 Status Report. Available at: https://www.fsb-tcfd.org/publications/tcfd-2018-status-report/

TCFD. (2022). Task Force on Climate-related Financial Disclosures: 2022 Status Report. Available at: https://assets.bbhub.io/company/sites/60/2022/10/2022-TCFD-Status-Report.pdf

van Benthem, A.A., Crooks, E., Giglio, S., Schwob, E., & Stroebel, J. (2022). The effect of climate risks on the interactions between financial markets and energy companies. *Nature Energy*, *7*(8), 690-697. https://doi.org/10.1038/s41560-022-01070-1

Velte, P. (2021). Environmental performance, carbon performance and earnings management: Empirical evidence for the European capital market. *Corporate Social Responsibility and Environmental Management*, *28*(1), 42-53. https://doi.org/10.1002/csr.2030

Wang, Q. (2023). Financial effects of carbon risk and carbon disclosure: A review. *Accounting & Finance*, 00, 1-45. https://doi.org/10.1111/acfi.13090

Watts, R., & Zimmerman, J. (1986). *Positive Accounting Theory*. Prentice-Hall, Englewood Cliffs, NJ.

Wells, K. (2020). Who manages the firm matters: The incremental effect of individual managers on accounting quality. *The Accounting Review*, *95*(2), 365-384. https://doi.org/10.2308/accr-52505

Zhang, H., & Zhang, J. (2023). Political corruption and accounting choices. *Journal of Business Finance & Accounting*, *50*(3-4), 443-481. https://doi.org/10.1111/jbfa.12646

APPENDIX A

Variable Definitions

Variable		***Definition***
AC_t	=	an indicator variable equal to 1 if the firm chooses the successful efforts (SE) method and 0 if the firm chooses the full cost (FC) method in year t;
$CCRD_t$	=	the measurement of the firm's CCR disclosure; equal to1, 2, or 3 if the firm discloses climate change risk information inone, two, or three sources from the SEC Form 10-K, CDP Report, and Corporate Sustainability Report in year *t*, and 0 otherwise;
REV_t	=	the firm'stotal revenue for year t;
AGE_t	=	the firm'slisting age at the end of year t;
$EXPR_t$	=	the firm's capital expenditures divided by operating income for year t;
LEV_t	=	the firm's debt divided by shareholders' equity for year t.