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RESEARCH ARTICLE

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Does clean technology weaken the environmental impact on the financial performance? Insight from global oil and gas companies

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Abstract

This study aims to clarify the relationship between environmental performance and financial performance by introducing clean technology as the moderating variable. We contest two major theories, natural resource-based view theory and neoclassical theory, to reveal a comprehensive understanding of environmental performance's impact on financial performance. The hypotheses are tested on 111 global oil and gas companies using dynamic panel generalized method of moments (GMM). Our analysis reveals three key findings. First, lower environmental performance leads to lower financial performance confirming the natural resource-based view theory. Second, clean technology has no significant effect on financial performance, arguing the marginal abatement cost. Finally, our results report that clean technology has no impact on increasing financial performance during high waste spills or high emissions. Theoretical and practical implications resulting from the adoption of clean technology to moderate the environmental impact on financial performance are also discussed.

KEYWORDS

clean technology, environmental performance, financial performance, oil and gas industry

1 | INTRODUCTION

Studies on the environmental impact on financial performance (FP) continue to be heavily debated amid the conflicting empirical evidence and theoretical disagreement documented in empirical environmental studies. On one side, the proponents of the natural resource-based view theory argue that environmental issues hinder contingency cost, whereas mitigating environmental risk is good for economic performance (Cordeiro & Sarkis, 1997; Fujii et al., 2013; Porter, 1991; Sangle, 2011). On another side, the neoclassical theory's proponents address marginal abatement costs (Palmer et al., 1995; Walley & Whitehead, 1994; Wu et al., 2019). The premise of neoclassical theory is that efforts on reducing environmental cost generate an additional cost; hence, it decreases the marginal net benefits. A meta-analysis study from Horváthová (2010) confirms this conflicting view by reporting mixed findings for environmental performance (EP) and FP association.

One reason for these mixed findings may be due to the technology used in mitigating environmental costs. Filbeck and Gorman (2004), Hizarci-Payne et al. (2021), and Sangle (2011) address the importance of environmentally friendly technologies in the production process. Companies that spend more of their resources on

Abbreviations: CleanTech, clean technology; EMS, Environmental Management System; EP, environmental performance; FP, financial performance; GMM, generalized method of moments; ROA, return on assets; ROE, return on equity.

clean technology to mitigate environmental costs relatively gain a competitive advantage over their competitors. Given the importance of clean technology to financially benefit companies in mitigating environmental costs, this paper bridges this gap in the literature and empirically addresses clean technology as the moderating factor in strengthening the EP–FP relationship.

Theoretically, a company can minimize its environmental impact on FP by adopting clean technology. Research findings from Hart (1997), King and Lenox (2001), and Severo et al. (2015) argue that adopting clean technology in EP often provides FP. Clean technology promotes sustainable development for companies, spreading the philosophy of eco-efficiency and eco-friendly to enhance competitiveness, social responsibility, and organizational sustainability. It refers to a procedural approach or method to production demanding all production phases should be addressed to minimize environmental risk. The clean technology context is more about avoiding environmental damage at the source. Hence, companies with clean technology may have better performance in mitigating environmental issues.

This study thus reinvestigates the relationship between EP and the FP of oil and gas companies worldwide. Unlike prior similar studies (Brahmana & Ono, 2020; Filbeck & Gorman, 2004; Horváthová, 2012), this study introduces clean technology as the moderating variable in revealing whether a company with clean technology might have a different level of FP for their environmental issue. We are not interested in the process's initial steps (i.e., research and development [R&D] activities) or the postenvironmental issue (i.e., clean-up activities and temporal effect). Instead, we focus on two critical issues. First, we focus on the diffusion effect of clean technology among oil and gas companies. For this purpose, we model companies with clean technology that will have better FP. Prior findings from Milliman and Prince (1989), Requate and Unold (2003), and Severo et al. (2015) examine the influence of environmental regulation on the adoption of clean technology, including pollution abatement. Then, we focus on how clean technology shapes the association between EP and FP.

Our study makes several contributions. First, we contest two major environmental economic theories but weakly tested: clean technology is the moderating factor in overcoming the neoclassical theory about abatement cost and integrating it with natural resource-based view theory. We find support for that argument. Our results reveal that a company's FP with clean technology has no significant difference from companies without clean technology. These results are counter to one of the most fundamental recommendations typically made based on neoclassical theory.

Second, we document the empirical findings of EP's effect on oil and gas companies' FP. This industry is one of the main contributors to environmental damages. Our findings imply that oil and gas companies should rethink their environmental strategy towards clean technology. Adopting clean technology cannot reduce the environmental impact on FP. It has to be beyond that with a complete ecosystem of an environmentally friendly business process. It is consistent with Filbeck and Gorman (2004) and Porter and van der Linde (1995), who address an environmentally friendly business process as a strategic resource.

The remainder of this paper is structured as follows. Section 2 formulates the hypotheses. Data, model specification, and variable definitions are described in Section 3, whereas the subsequent section provides the results and discusses the key findings. Section 5 concludes the study.

2 | THEORETICAL ARGUMENT AND HYPOTHESIS DEVELOPMENT

The main argument of EP–FP association is based on natural resource-based view theory (Hart, 1995; Horváthová, 2010). This theory argues that the EP has significant effects on FP, whereas if a company can reduce its pollution or waste spills, it can minimize its financial costs and liabilities (Lorraine et al., 2004; Porter & van der Linde, 1995). Specifically, companies with environmentally sustainable economic activity will have a better competitive advantage than those without any effort to face environmental issues.

Conversely, the neoclassical theory argues that improved EP leads to an increased cost. The premise of this theory is that the company needs to spend a large amount of investment on environmental mitigation to have improved EP. This environmental investment leads to a decrease in marginal net benefits. Higher capital expenditure in an effort for an environmentally friendly business process leads to marginal abatement cost, and hence, the profit margin will be lower (Brahmana & Ono, 2020; Fujii et al., 2013; Horváthová, 2010; Palmer et al., 1995).

Given the excessive contradicting empirical findings on the relationship between EP and FP based on the natural resource-based view and neoclassical theory, it is surprising that the theoretical assumptions and empirical findings have not yet exploited it further. Indeed, several attempts have been employed by introducing moderating variable as a theoretical explanation for this disagreement (e.g., corporate governance by Nguyen et al., 2021; firm size effect by Konar & Cohen, 2001; firm efficiency by Filbeck & Gorman, 2004; industry sensitivity by Qureshi et al., 2020; profitability effect by Elsayed & Paton, 2005; and temporal effect by Horváthová, 2012). However, little is known about the effect of clean technology on the relationship between EP and FP, a gap that this research aims to tackle.

2.1 | EP and FP

We propose that EP has a significant effect on FP. According to the meta-analysis of Horváthová (2010), the association between EP and FP is mixed. It is reported that about 15% of studies report a negative effect, 30% report no effect, and 55% report a positive effect. We develop our reasoning by adopting natural resource-based view theory postulation. The natural resource-based view predicts that improved EP leads to better FP.

EP is treated as strategic resources and connotes as an indicator of deficient, wasteful, or inefficient use of organizational resources

(Porter & van der Linde, 1995; Seman et al., 2019). The seminal paper of Ullmann (1985) exhibits a descriptive analysis of prior environmental studies between EP, environmental disclosure, and FP of a company. However, inconsistent results existed due to the ambiguity of the theory used, lack of appropriate data, and inappropriately used key terms that open for further investigation of the study matter. Additionally, Soto-Onate and Caballero (2017) is the closest research with ours. Their review is about how oil spills will affect institutional performance. They argue substantial heterogeneity in terms of performance across nations due to oil spills. It is consistent with Henri et al. (2016). Testing the effect with 319 Canadian manufacturing companies, they found that environmental cost influences FP.

Extending this line of inquiry, we argue that the marginal abatement cost may also incur this EP–FP relationship. In neoclassical theory, the company is presumed to be well informed and rational and seeks profit maximization. Spending more on environmental mitigation would result in higher investment (Wu et al., 2019). This mitigation activity will add extra costs and deduct the performance of a company. Jaggi and Freedman (1992) confirm this proposition by revealing that pollution performance improvement reduces pulp and paper companies' performance. Boyd et al. (2002) have similar conclusions, whereas they find that production growth would be diminished when companies introduce environmental control or energy efficiency.

Therefore, EP effects on FP can be evaluated along with two aspects. First, companies with a higher level of EP will gain higher FP as addressed by natural resource-based view theory. Second, EP will lead to low FP due to marginal abatement cost, as addressed by neoclassical theory. Therefore,

H1: Lower EP leads to lower company's FP.

2.2 | Clean technology and company FP

Empirical findings in environmental studies argue that clean technology is an integrated environmental strategy from process to end user that prevents environmental risk, which is closely related to business performance (Claver et al., 2007; Morioka & de Carvalho, 2016). Different clean technology investment efforts may have different FP implications (Zeng et al., 2010). The absence of clean technology may hurt environmental performance even further (Claver et al., 2007; Junquera et al., 2012; Morioka & de Carvalho, 2016). Clean technology brings lower contingency cost and lower uncertainty; thus, it enhances the company FP (Junquera et al., 2012; Morioka & de Carvalho, 2016).

Following this line of thought, we consider that clean technology can reduce EP to a greater extent, thus building its FP. According to a meta-analysis carried out by Albertini (2013) that documented 52 studies over 35 years, most studies have reported that clean technology adoption has a positive correlation to a company's FP. It is confirmed by the findings from Ruggiero and Lehkonen (2017), whereas 66 large electric utility companies had a better business performance after adopting renewable energy. Therefore, the second hypothesis of this research is that:

H2: FP of companies with clean technology outperforms the performance of companies without clean technology.

2.3 | The moderating effect of clean technology

The review of the EP–FP relationship shows a slight majority of negative relationships; hence, we offer clean technology as the moderating variable for that relationship. We believe that a company has to have clean technology to have a better FP of environmental issues. This view is built from an environmental innovation perspective, where it argues that clean technology might change the effect of EP on FP (King & Lenox, 2001). Clean technologies result from other environmental innovations, which imply an integrated change in the production process. A company that adopts this clean technology has an advantage in reducing pollution, spills, or environmental cost, leading to better FP (Horváthová, 2012).

Prior findings from Burritt et al. (2009) argue that companies that do not adopt clean technology will be hard to reduce their environmental impacts. As a consequence, it affects their competitiveness. Severo et al. (2015) state that a company should consider a clean production approach to generate better EP, contributing to its dynamic. Consistent with those findings, Wong et al. (2012) found that companies with clean technology adoption, such as green operation, will have better FP because clean technology mitigates environmental damage. Consequently, a third hypothesis emerges as follows:

H3: The positive relationship between EP and FP would be strengthened by the use of clean technology.

In sum, this research has three hypotheses. The first hypothesis (H1) is about the positive relationship between EP and FP. We then have our second hypothesis (H2) about the effect of clean technology on FP. Lastly, our third hypothesis is a moderating effect, where the interaction term between EP and clean technology has significant effects on FP. Figure 1 shows our research framework.

3 | METHODOLOGY

3.1 | Data and sample

The sampling frame is all oil and gas companies Fortune Global List. We exclude companies with unavailable data. Preceding the data analysis, we do variable winsorizing at the 1st and 99th percentile to reduce outliers' influence. The final list covers 111 oil and gas companies over 6 years of 2012–2018. There are two reasons why we choose 2012 to 2018. First, it is related to data availability. The financial information and EP provided on the company website and ESG Asset4 are most likely started in that period. Second, if the

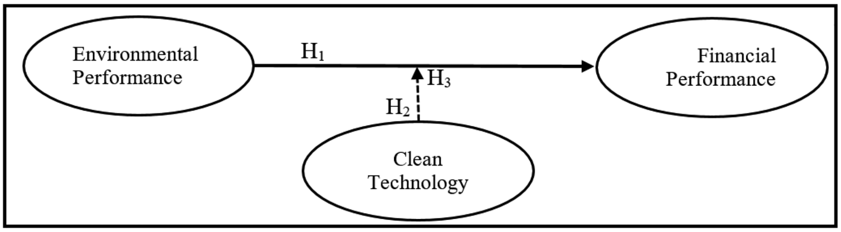

FIGURE 1 Proposed model of hypothesis

company provided data earlier than 2012, the panel data have a concomitant variation issue. We obtain the data from two sources: (i) annual report (for financial information) and (ii) ESG Asset4 (for the EP and clean technology).

3.2 | Variable definition

Because this research's main objective is to investigate the moderating effect of clean technology on the relationship between EP and FP, we briefly discuss all the variables used in the main analysis. Following that, the model specification is introduced. A complete list of the variable definition is provided in Appendix 0.

3.3 | Financial performance

We measure FP by using return on equity (ROE) and return on assets (ROA).

3.4 | Environmental performance

We use two measures for environmental factors, namely, (i) CO emission and (ii) waste spills. These two measures are fit to describe the outputs of EP (Al-Tuwaijri et al., 2004; Trumpp & Guenther, 2017) for the oil and gas characteristics on environmental cost. Oil and gas companies are arguably much related to CO emission and spills. CO emission is defined as total carbon emissions produced by an oil and gas company (Trumpp & Guenther, 2017). The waste spills are defined as the spill volume per year of oil and gas companies (Soto-Onate & Caballero, 2017). Note that those two EP measures are interpreted as an inverse relationship with EP. In other words, higher (lower) CO emission or higher (lower) waste spills indicate deteriorated (improved) EP.

3.5 | Clean technology

Our clean technology is a dummy variable. We argue that because clean technology is about a procedural approach or a method of using technology in minimizing environmental risk, a company with clean technology will be valued as "1," else, "0." Additionally, it is noteworthy that the oil and gas companies do not disclose their total value of clean technology investment or the number of clean technology or type of clean technology. The only available data are about whether the company uses clean technology or not.

3.6 | Control variables

Environmental economic studies have extensively explored the determinant of FP from an environmental perspective. We adopt the key factors from those studies as the control variable to isolate the independent effect of EP. Our control variables are more on company characteristics, which are leverage, growth, and size. It is in line with the theoretical setting of the oil and gas industry.

The company characteristics are year-end data retrieved from Thomson Datastream. We have leverage that is measured as the ratio of total debt to total assets (*Leverage*). Firm size is measured by the natural logarithm of total assets (*Size*). Growth is defined as annual sales growth.

Because this study is also part of environmental studies, findings from Erauskin-Tolosa et al. (2020), Garrido et al. (2020), and Heras-Saizarbitoria et al. (2011) surmise the importance of ISO 14001 certification or Environmental Management System (EMS) certification as the predictor of FP in oil and gas companies. Especially in the context of EP, EMS certification has a significant role in changing the financial variation of an oil and gas company. Therefore, we add EMS as part of the control variable. A firm with EMS certification is given "1," and a firm without EMS certification is given "0." Note that EMS certification is an ISO certification, which is different from the use of clean technology.

3.7 | Model specification

We follow the paper by Jaggi and Freedman (1992), and Horváthová (2012) specifies a linear regression model with all contemporaneous variables. The baseline model is built from the function of FP, which is leverage, size, and growth. However, as this research is about environmental studies, it is imperative to add environmental certification like EMS as another control variable. Therefore, the baseline model is about FP as the function of leverage, size, growth, and EMS.

We extend this specification by introducing EP into the model estimation. It forms a new FP function, whereas now leverage, size, growth, EMS, and EP is the predictor for profitability. Finally, we follow Balli and Sørensen (2013) and Brambor et al. (2006) to establish our full model. The clean technology, which is our moderating variable, is introduced to the new specification, and we build the interaction term between clean technology and EP for the moderating effect. In the end, our model specification is as follows:

$$\begin{aligned} \mathit{Financial\ performance}_{i,t} = {} & \beta_0 + \beta_1 \mathit{Env\_Perf}_{i,t} + \beta_2 \mathit{CleanTech}_{i,t} \\ & + \beta_3 (\mathit{Env\_Perf} * \mathit{CleanTech})_{i,t} + \beta_4 \mathit{Leverage}_{i,t} \\ & + \beta_5 \mathit{Size}_{i,t} + \beta_6 \mathit{Growth}_{i,t} + \beta_7 \mathit{EMS}_{i,t} \\ & + \sum\nolimits_{j=1}^{j-1} \gamma_{102j} \mathit{Country}_{i,t} + \sum\nolimits_{T=1}^{T-1} \gamma_{6t} \mathit{Year}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{1}$$

$Country_{i,t}$ is a vector of country-specific dummy variables constructed based on the country classification to control for time-invariant country effects, where $Country_i = 1$ if firm i is from country j and 0 otherwise. $Year_{i,t}$ is year dummies that were included to control for common shocks, where $Year_{i,t} = 1$ if firm i is in year t and 0 otherwise.

4 | FINDINGS

4.1 | Descriptive statistics

Table 1 presents the summary statistics for the variables in estimation model (1). Focusing on the key variable, the mean value of the ROE is 7.11%, which is slightly lower than the average firm's ROE of 12% reported by Dayanandan and Donker (2011) or reported by San Ong et al. (2017). The explanation for that discrepancy is that the oil and gas industry, during their research period (2008–2012), enjoy lower competition and higher oil prices. Bloomberg and CSIMarket database report that the average ROE for oil and gas companies after 2012 was around 4–6%. Therefore, our financial data are tallied with the anecdotal evidence implying our sampling frame is robust. Meanwhile, Table 1 reports that the ROA is averagely at 3.11%, with a median value of 4.42%. These figures are consistent with the report by San Ong et al. (2017). Overall, the descriptive statistics show that oil and gas companies' profitability is averagely at 7.11% (ROE) and 3.11% (ROA).

The main independent variables, carbon emission and volume spills, have attractive data distribution. The CO emission data imply that half of the oil and gas companies reported 15.1 emissions (in log form). For the spills, half of the oil and gas companies do not have spill waste. It implies the EP of oil and gas companies is well distributed. There were half companies with lousy EP and the rest with good EP (zero emission). For clean technology, our descriptive statistics reveal that approximately 30% of oil and gas companies have clean technology. Perhaps, this is the explanation for companies with zero emissions.

In terms of control variables, the mean value for leverage shows 54.82%, indicating that, averagely, oil and gas companies rely more on debt financing. Meanwhile, this industry's revenue growth was 12.01%, aligned with oil and gas prices' commodity price cycle. Additionally, 53% of the companies with EMS certification indicated half of our sample did pursue emission mitigation certification.

4.2 | Correlation analysis

Table 2 presents the correlation matrix for the variables of estimation model (1). The correlation between the explanatory variables and FP provides a preliminary view of their univariate relationship. The findings fit our expectations for three reasons. First, the correlation between ROE and ROA is high, confirming that ROE and ROA measuring similar aspects of FP. Second, the main explanatory variables: carbon emission and environmental spills, negatively affect FP measures. It implies that high environmental risks of an oil and gas company are correlated with low FP. Lastly, the correlation among main explanatory variables varies.

Given several independent variables have a medium size of correlation (for instance, the EMS), we argue that it does not imply multicollinearity. The correlation among the explanatory variables is a good basis for multicollinearity indication. We test further all the variables under the variance inflation factor (VIF) to ensure no

TABLE 1 Summary statistics

Variable	Min	Median	Mean	Max	SD
ROA (%)	−114.97	4.42	3.11	63.59	10.19
ROE (%)	−557.73	8.01	7.18	88.61	32.05
Leverage (%)	12.40	60	54.82	90.00	19.49
Growth (%)	10.01	11.22	12.01	69.78	3.19
Size (LN)	5.22	7.61	7.85	11.15	1.09
EMS (dummy)	0.00	1	0.53	1.00	0.50
CO emission (LN)	0.00	15.1	12.10	18.66	6.55
CO emission (value)	0.00	3,486,323	12,300,000	127,000,000	22,500,000
Spills (LN)	0.00	0	0.86	13.48	1.66
Spills (value)	0.00	0	4935	717,761	56,211
Clean technology (dummy)	0.00	0	0.29	1.00	0.46

TABLE 2 Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ROA	1								
(2) ROE	0.8242*	1							
(3) Leverage	−0.0904*	−0.1979*	1						
(4) Growth	−0.1449*	−0.0947*	0.0659	1					
(5) Size	0.2003*	0.1549*	0.0342	−0.2597*	1				
(6) EMS	0.1307*	0.1151*	0.0124	−0.2638*	0.3084*	1			
(7) CO	−0.1340*	−0.0723*	−0.1186*	−0.0158	0.1969*	0.1975*	1		
(8) Spills	−0.1879*	−0.1829*	−0.0083	0.0249	−0.0772*	0.0976*	0.2255*	1	
(9) CleanTech	0.1213*	0.1163*	−0.0539	−0.2138*	0.2470*	0.2174*	0.1129*	−0.0353	1
Multicollinearity (VIF)									
	Mean	CO	Spills	CleanTech	Interaction term	Leverage	Growth	Size	EMS
CO emission	1.78	1.36		3.09	3.40	1.03	1.15	1.21	1.21
Spills	1.24		1.23	1.41	1.50	1.03	1.15	1.20	1.19

*Denotes statistical significant at 5% level.

multicollinearity incurred and found out that the VIF scores are below 10. It means that even though the firm size and environmental cost are highly correlated, our estimation models are free from multicollinearity issues.

4.3 | Panel regression results

The results for estimation model (1) are presented in Tables 3 and 4. Each table has eight columns. Columns 1, 2, 5, and 6 were estimated by following the recommendation of Petersen (2009). It accommodates the possible existence of within-cluster correlation by estimation of the regression model using fixed-effect double-clustered standard errors. We cluster the country effect and the period effect. The results in columns 1 and 5 are the estimation without the moderation effect (baseline model). Meanwhile, columns 2 and 6 results are from the full model under the robust fixed-effect estimation.

For robustness reasons, we also estimate the model under two-way effect panel regression and report it in columns 3 and 7. Finally, we also specify the model under the two-step system generalized method of moments (GMM) model to address endogeneity concerns. Given the difficulty of finding a strictly exogenous external instrument, we follow Wintoki et al.'s (2012) advice in using the lagged dependent variable of FP. The results are presented in columns 4 and 8. To conserve space, we only report the results of the two-step GMM approach.

4.4 | CO emission and FP

In H1, we hypothesize a positive relationship between EP and FP of oil and gas companies. Column 4 of Table 3 reveals a negative association between carbon emission (CO) and ROE ($\beta = -.861$, $SE = 0.257$). It suggests that higher CO emission will decrease the ROE of the oil and gas companies. This result suggests that the increment of CO is associated with a 0.861% decrease in ROE.

Column 8 findings of Table 3 reveal the same conclusion, whereas higher CO emission leads to lower ROA ($\beta = -.335$, $SE = 0.117$). It suggests that the increment of the CO will decrease the ROA of oil and gas companies. Practically, the results indicate that each increment of CO emission is associated with a 0.335% decrease in ROA. Both column 4 and column 8 findings contradict the sign proposed in H1. Hence, we surmise that when oil and gas companies experience high CO emissions, it will deteriorate their FP.

The findings for the clean technology variable reject the second hypothesis. Column 4 surmises that the ROE of oil and gas companies with clean technology has no significant difference than the ROE of oil and gas companies without clean technology. Column 8 shares a similar conclusion. It shows that the ROA of oil and gas companies with clean technology has no significant difference than oil and gas companies' ROA without clean technology. It suggests that clean technology does not affect the FP of the oil and gas company. Adopting clean technology or not adopting it will not influence FP. Theoretically, these results rebuke the marginal abatement cost hypothesis, which states that adopting clean technology will harm a company's FP. It further explains that having clean technology adds extra cost to the company, and as a consequence, it affects the company's performance. However, our results reveal that clean technology adoption has no significant effect on FP. Managers should not be uneasy about marginal abatement costs from clean technology because it might not deteriorate or improve their FP.

Our main argument is about the effect of clean technology adoption in assisting oil and gas companies to gain better FP in facing their environmental issue. Columns 4 and 8 reveal that the interaction term between CO emission and clean technology has no significant effect on FP. It implies that clean technology has no moderating role

TABLE 3 CO emission and financial performance

	ROE				ROA			
	Baseline (1)	F/E (2)	Two-way effect (3)	GMM (4)	Baseline (5)	F/E (6)	Two-way effect (7)	GMM (8)
Perf ($t-1$)				0.176*** (0.025)				0.301*** (0.034)
Environmental performance (CO emission)	−0.726*** (0.202)	−0.918*** (0.285)	−0.918** (0.452)	−0.861*** (0.257)	−0.322*** (0.076)	−0.367*** (0.090)	−0.918** (0.452)	−0.335*** (0.117)
CleanTech		−2.289 (7.271)	−2.289 (2.683)	8.002 (8.039)		−0.201 (0.984)	−2.289 (2.683)	1.539 (3.294)
CO * CleanTech		0.581 (0.548)	0.581* (0.328)	0.454 (0.320)		0.133* (0.081)	0.581* (0.328)	0.129 (0.149)
Leverage	−0.363*** (0.106)	−0.351*** (0.102)	−0.351*** (0.061)	−0.597*** (0.104)	−0.062** (0.030)	−0.059** (0.029)	−0.351*** (0.061)	−0.232*** (0.033)
Size	4.663*** (1.488)	4.292*** (1.343)	4.292** (1.926)	29.439* (17.558)	1.865*** (0.626)	1.758*** (0.584)	4.292** (1.926)	11.482** (5.535)
Growth	−0.167 (0.198)	−0.058 (0.196)	−0.058 (0.425)	−0.214 (0.199)	−0.203** (0.090)	−0.172* (0.091)	−0.058 (0.425)	−0.192 (0.143)
EMS	6.026* (3.123)	5.988** (3.023)	5.988** (3.040)	3.563* (2.013)	1.935* (1.073)	1.890* (1.075)	5.988** (3.040)	1.446 (1.002)
Constant	−1.89 (17.409)	−0.338 (17.252)	−0.338 (22.307)	−186.54 (137.687)	−2.816 (6.528)	−2.44 (6.348)	−0.338 (22.307)	−72.295* (43.210)

Note: The definitions for all the variables are provided in Appendix 0. This table presents the estimation results for CO emission as the independent variable. The baseline model is estimated using robust fixed effect. The full model is estimated using three approaches: robust fixed effect, two-way clustered effect, and two-step GMM. We report the coefficient value. Meanwhile, the standard errors are revealed in parentheses.

*Statistically significant at 10% level.

**Statistically significant at 5% level.

***Statistically significant at 1% level.

TABLE 4 Spills and financial performance

	ROE				ROA			
	Baseline (1)	F/E (2)	Two-way effect (3)	GMM (4)	Baseline (5)	F/E (6)	Two-way effect (7)	GMM (8)
Perf ($t-1$)				0.212*** (0.026)				0.301*** (0.037)
Environmental performance (waste spills)	−3.564*** (1.211)	−3.814*** (1.439)	−3.814* (2.002)	−1.997* (1.012)	−1.130*** (0.400)	−1.166** (0.468)	−1.166* (0.692)	−2.371*** (0.806)
CleanTech		2.334 (2.133)	2.334 (2.304)	11.317 (8.135)		0.797 (0.522)	0.797 (0.956)	0.79 (2.699)
Spill * CleanTech		1.658 (1.745)	1.658 (3.681)	1.539 (2.542)		0.263 (0.495)	0.263 (1.217)	1.969** (0.819)
Leverage	−0.334*** (0.108)	−0.322*** (0.106)	−0.322*** (0.074)	−0.484*** (0.087)	−0.049* (0.029)	−0.046 (0.029)	−0.046*** (0.012)	−0.211*** (0.027)
Size	3.311*** (1.238)	2.995*** (1.122)	2.995** (1.231)	21.419 (15.788)	1.342** (0.544)	1.262** (0.516)	1.262** (0.608)	9.427** (4.704)
Growth	−0.226 (0.196)	−0.173 (0.176)	−0.173 (0.371)	−0.308* (0.165)	−0.237*** (0.087)	−0.221*** (0.085)	−0.221 (0.161)	−0.275 (0.203)
EMS	6.095** (3.101)	5.716* (3.059)	5.716 (5.356)	3.653 (3.680)	1.755 (1.086)	1.643 (1.083)	1.643 (2.016)	1.329 (1.398)
Constant	2.047 (16.608)	2.59 (16.344)	2.59 (18.640)	−136.306 (123.947)	−1.87 (6.347)	−1.769 (6.276)	−1.769 (7.333)	−58.089 (37.019)

Note: The definitions for all the variables are provided in Appendix 0. This table presents the estimation results for waste spills as the independent variable. The baseline model is estimated using robust fixed effect. The full model is estimated using three approaches: robust fixed effect, two-way clustered effect, and two-step GMM. We report the coefficient value. Meanwhile, the standard errors are revealed in parentheses.

*Statistically significant at 10% level.

**Statistically significant at 5% level.

***Statistically significant at 1% level.

TABLE 5 Subsampling

	Clean technology (CO emission model)				Clean technology (spill model)			
	Without		With		Without		With	
	ROE (1)	ROA (2)	ROE (3)	ROA (4)	ROE (5)	ROA (6)	ROE (7)	ROA (8)
Environmental	−0.912*** (0.274)	−0.370*** (0.091)	−0.324* (0.190)	−0.178* (0.094)	−3.775* (2.244)	−1.104* (0.615)	−2.911*** (1.080)	−1.201** (0.485)
Leverage	−0.272*** (0.065)	−0.044** (0.021)	−0.470*** (0.096)	−0.066** (0.031)	−0.222*** (0.069)	−0.045** (0.022)	−0.489*** (0.093)	−0.072** (0.029)
Size	5.474*** (1.527)	2.314*** (0.676)	−0.353 (1.765)	−0.282 (0.795)	4.216*** (1.359)	1.905*** (0.608)	−0.829 (1.517)	−0.591 (0.718)
Growth	0.024 (0.321)	−0.15 (0.123)	−1.719 (1.823)	−0.236 (0.702)	−0.106 (0.325)	−0.207 (0.129)	−1.208 (1.803)	−0.052 (0.729)
EMS	8.916* (4.641)	2.406 (1.595)	−0.499 (3.456)	0.706 (1.266)	8.163* (4.562)	1.804 (1.612)	0.648 (3.373)	1.244 (1.288)
Constant	−15.918 (15.011)	−7.962 (5.696)	64.363** (25.771)	15.309 (9.832)	−14.27 (13.951)	−8.163 (5.480)	60.826** (22.673)	14.347 (8.554)

Note: The definitions for all the variables are provided in Appendix 0. This table presents the estimation results for the subsampling of two groups: (i) oil and gas companies with clean technology and (ii) oil and gas companies without clean technology. The full model is estimated using a two-way clustered effect. "Environmental" denotes environmental performance. The estimation results for CO emission as independent variables are reported in columns 1 to 4. Meanwhile, columns 5 to 8 are the waste spills' results. We report the coefficient values. Meanwhile, the standard errors are revealed in parentheses.
*Statistically significant at 10% level.
**Statistically significant at 5% level.
***Statistically significant at 1% level.

in weakening the negative effect of environmental cost on FP, which is against our third hypothesis. This result means that high CO emissions will still deteriorate a company's FP even though it already uses clean technology in its business process.

4.5 | Waste spill and FP

Another measurement of the environmental cost for this research is waste spills. We re-estimate the model by changing CO emissions as the main independent variable to waste spills as the main independent variables. Table 4 reports the results.

For the first hypothesis, the results from column 4 and column 8 of Table 4 surmise that the spills have a negative relationship with oil and gas companies' FP. First, we reveal the negative relationship between spill's volume and the ROE ($\beta = -1.997$, $SE = 1.012$). It implies that higher waste spill leads to decreasing ROE. The same conclusion is for the ROA, where it also shows an increase of waste spill decreases the ROA ($\beta = -2.371$, $SE = 0.806$). Overall, our results support the hypothesis with a conclusion that the spill's volume will harm oil and gas companies' FP.

For the clean technology variables, the conclusion remains the same. Table 4 also surmises that clean technology has no significant influence on oil and gas companies' FP. It reveals that the FP between companies with clean technology and those without technology has no significant difference. Adopting clean technology for waste spills might not be beneficial or detrimental to oil and gas companies' FP.

The moderating results in Table 4 show that clean technology has no impact on the relationship between waste spills and FP in oil and gas companies. Clean technology has failed to weaken or strengthen the negative relationship between waste spills and FP. In other words, in a situation of having a waste spill, an oil and gas company with clean technology will not have any significant profitability difference from the oil and gas company without clean technology. Hence, we can conclude that the third hypothesis is rejected.

In the case of control variables, our results reveal that leverage and size are important company characteristics for FP. A statistically negative relationship can be seen between the leverage and the FP, implying that higher leverage might harm the oil and gas companies' FP. The company size has a positive impact on the FP, indicating that big-sized companies have better FP, which is aligned with the economies of scale proposition (Conca et al., 2021).

4.6 | Robustness check with subsampling

We perform a robustness check to reveal clean technology's role in the relationship between EP and FP. First, we divide the sample into two groups: clean technology and no-clean technology. Then, we re-estimate model (1) by dropping the clean technology variable. Table 5 reports the results with the detail as follows. Columns 1, 2, 5, and 6 are the estimation results with the sample of oil and gas companies without clean technology. Meanwhile, columns 3, 4, 7, and 8 are the results with the sample of oil and gas companies with clean technology.

For oil and gas companies with clean technology, the results reveal that EP positively affects FP. It shows a negative sign of CO emission and spills on the FP. The CO emission's result shows a negative effect on ROE ($\beta = -.324$, $SE = 0.190$) and ROA ($\beta = -.178$, $SE = 0.094$). It means an increase in CO emissions leads to a decrease in the clean technology adopters' FP. For the waste spills, it has the same conclusion. It has a negative effect on ROE ($\beta = -2.911$, $SE = 1.080$) and ROA ($\beta = -1.201$, $SE = 0.485$). It means that increasing waste spills will decrease the clean technology adopters group's FP.

Interestingly, the nonclean technology adopter group results have a similar conclusion. The CO emissions of companies without clean technology have deteriorated the ROE ($\beta = -.912$, $SE = 0.274$) and the ROA ($\beta = -.370$, $SE = 0.091$). It implies that higher CO emission will reduce the FP of the nonclean technology adopter group. The waste spills also harm the ROE ($\beta = -3.755$, $SE = 2.244$) and ROA ($\beta = -1.104$, $SE = 0.615$). A high volume of waste spills would reduce the FP of the nonadopters.

In sum, the findings from Table 5 confirm that CO and spills are harmful to company FP. It aligns with our argument about having better EP makes companies perform better financially. However, having clean technology does not mean the FP of good EP will be better. As we can see from Table 5, mitigating CO emissions and waste spills are crucial factors rather than the clean technology adoption. Indeed, the negative coefficient values without clean technology much bigger than the clean technology adopter group implying clean technology might have a less detrimental effect on CO emission and waste spills. However, clean technology cannot weaken that detrimental effect. It is noteworthy that our results do not suggest that clean technology will have no value for oil and gas companies. It is not in our research scope. We remark that clean technology, so far, was still not able to moderate the FP of environmental mitigation issues.

5 | CONCLUSIONS

This research highlighted the role of clean technology in tackling the impact of EP on FP. We contest two major theories: natural resource-based view and neoclassical theory, to explain the association between EP and FP. Unlike Arocena et al. (2021), our main conclusion is that green technology has no significant effect of weakening the environmental impact on FP.

Our results suggest that oil and gas companies should revise the motive of adopting clean technology to reduce EP. Clean technology adoption might help the company's reputation, but the current technology cannot help the company reduce spill and emission impact on performance. There are three reasons for this result. First, the environmental impact on FP is much more significant than the mitigation done by clean technology. The spills and emission give higher contingency costs and reputation costs than the cost elimination from clean technology (Hizarci-Payne et al., 2021). Second, perhaps the current clean technology is not advance yet in mitigating the impact of spills and emissions on FP. It needs further innovation of clean technology in the future to reduce the environmental impact on FP (Conca et al., 2021). Lastly, clean technology might need a whole clean technology adoption ecosystem and an extended period to adopt. Adopting advanced green technology might be a good move to mitigate the climate change issue. However, if the companies still do not pursue thoroughly pristine ecosystems in their business chain, the clean technology would not weaken CO and spills' harmful effect on companies performance. Further, adopting clean technology might not give incremental contributions to FP in the short run. It needs time to benefit the companies financially.

Our findings integrate neoclassical theory and nature resource-based view theory. It posits that EP such as CO emission and spills are bad for the oil and gas company's performance. However, clean technology cannot weaken the impact by generating better FP when there is an environmental cost. Proponents of marginal abatement costs may view this action as an additional burden because of the high capital expenditure of clean technology investment. Prior studies on the EP–FP relationship (i.e., Elsayed & Paton, 2005; Filbeck & Gorman, 2004; Horváthová, 2010, 2012; Konar & Cohen, 2001) have pointed out that the presence of moderating variable may improve the relationship. Therefore, we enrich the body of knowledge by revealing that clean technology would not weaken the FP of oil and gas companies EP. However, we stop short of claiming that clean technology is not adequate for environmental issues' FP. Our empirical setup does not allow us to make such a claim. We leave this for future research.

Our findings also have significant managerial and industrial implications. According to our findings, adopting clean technology will not deteriorate or improve a company's FP. It disproves the argument that adopting clean technology generates additional costs resulting in deteriorating FP. Extractive industries such as oil and gas may invest in clean technology as part of their social responsibility, primarily if investing in this clean technology does not hurt their FP. When the oil and gas company's managers are in the budgeting process for their capital expenditure, they should consider the outcome of investing in clean technology from the perspective of sustainable development. Other similar industries such as manufacturing or electronics may relook this issue. As our research findings are limited for oil and gas companies, it will be an interesting topic to test the role of clean technology in other industries with different research settings.

Additionally, our findings reveal that clean technology has failed to moderate the relationship between EP and FP. However, let us look further at our subsampling results. It stipulates that the magnitude of negative impact from the emission or spills is relatively lower for clean technology adopters than the nonadopters. Managers may adopt clean technology to slow down the negative impact. Still, the overall FP's impact will not be significantly different if managers do not adopt clean technology. This is why the decision to adopt clean technology should not rely on significant financial benefits. It should be from the perspective that adopting clean technology (i) will not generate financial impact, (ii) will give a modest contribution to the negative effect of the emission or spills, or (iii) is taken to increase the reputation (sustainable development).

However, all our findings need to be validated further research on other environmental perspectives to verify some facts about certain common characteristics embedded in those other environmental risks and other contingency costs. The focus of this study has been to examine the clean technology impact on the relationship between environmental factors, such as volume spills and environmental cost, and FP. Future research may examine the temporal effect. For example, those companies that have implemented clean technology for a long period of years may have better outcomes than those who have recently started clean technology. It can also be a company that invests in clean technology during the early stage of the clean technology boom and may have different benefits than companies that invest in the later period. Another extension can be further built upon this analysis within a strategic management perspective. First, more in-depth insight into the temporal effect of cash holding may affect clean technology decisions or affect the association between EP and FP. Second, the nonmarket strategy, such as political connection, can be another exciting extension of study for this analysis.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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APPENDIX A.

VARIABLE DEFINITION

Notation	Definition	Description
Financial performance		
ROE	Return on equity	Net income divided by equity
ROA	Return on assets	Net income divided by total assets
Environmental performance (ENV)		
Spills	Waste spills	The logarithm of total volume spills
CO	Carbon emission	The logarithm of total carbon emission
Moderating variable		
CleanTech	Adopting clean technology	Dummy variable; 1 if acquiring clean technology and 0 if it does not adopt clean technology
Control variables		
Leverage	Debt to equity	Total debt divided by total equity
Size	Size of firm in terms of total assets	The logarithm of total assets
Growth	Revenue growth (YoY)	The difference between this year revenue minus the last year revenue and then divided by the last year revenue
EMS	Environmental management system certification	Dummy variable; 1 if the company has EMS certification and 0 if it does not adopt clean technology