

**THE VALUE RELEVANCE OF CLIMATE-RELATED FINANCIAL DISCLOSURES:
AN EMPIRICAL INVESTIGATION OF TCFD-ALIGNED REPORTING AND FIRM
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Abstract

This study empirically investigates the connection of climate related financial disclosures in line with the Task Force on Climate-related Financial Disclosures (TCFD) framework and firm value in the Pakistani context. A panel data comprises of 620 firm-year observations of the firms included in the KSE-100 index from the Pakistan Stock Exchange (PSX) in the time frame 2019–2024, a subset of which is used to build a Climate Compliance Index (CCI) using content analysis of corporate sustainability reports, annual reports, and ESG disclosures required by the SECP based on the four TCFD pillars: governance, strategy, risk management, and metrics and targets. We use panel fixed-effects regression models with robust standard errors to show that, controlling for industry, year, and firm (size, leverage, and profitability) fixed effects, TCFD-aligned disclosure quality is (negatively) associated with firm value measured by Tobin's Q at a statistically significant level. This negative relationship is stronger for companies in high climate-risk sectors (Oil & Gas, Cement, Power Generation and Chemicals) and for companies with higher carbon intensity. We also observe that the negative association is weakened for firms that have a higher disclosure credibility as measured by third-party assurance. We find our results to be fairly stable over alternative model specifications, such as the generalized least squares estimation and the lagged independent variables to account for the potential reverse causality. The findings build upon the body of literature on the economic impacts of climate disclosure in emerging markets and provide empirical evidence from Pakistan, which is one of the most climate-sensitive countries in the world and has been ranked 179th out of 180 countries on the Environmental Performance Index 2024. The study has significant consequences for the Securities and Exchange Commission of Pakistan (SECP) and for corporate managers and investors who have had to deal with the changing requirements of mandatory ESG reporting, which will be fully mandatory for listed companies by 2029.

Keywords: Climate-Related Financial Disclosures, Tcfd, Firm Value, Tobin's Q, Climate Risk, Sustainability Reporting, Pakistan Stock Exchange, Emerging Markets, Panel Data

JEL Classification: G12, G14, G32, M41, Q54

I. Introduction

Climate change has become one of the most significant problems facing the world economy with wide-ranging consequences for strategic direction, risk management and investment decisions at the corporate level. Although Pakistan's share of the global GHGs is less than 1%, it is one of the most climate change sensitive



countries in the world. According to the Environmental Performance Index 2024, Pakistan is ranked 179th out of 180 countries with a terrible environmental performance. The devastating floods of 2022 which impacted more than 33 million people and inflicted losses of more than \$30 billion are also a vivid reminder of the physical threats climate change poses to the Pakistani economy, its business houses and capital markets (Abse et al., 2025).

In 2015, the Financial Stability Board (FSB) launched the Task Force on Climate-related Financial Disclosures (TCFD) in response to increasing stakeholder requests for uniform, comparable and reliable disclosure of climate-related information. Since then, the TCFD framework, with its four thematic pillars of governance, strategy, risk management, and metrics and targets, has become the major international benchmark for reporting on climate change and finance. The Pakistan Stock Exchange (PSX) has actively participated in this global movement by organizing trainings on TCFD recommendations, in collaboration with the SSE, CDP and IFC, while the Securities and Exchange Commission of Pakistan (SECP) has announced the adoption of IFRS S1 and S2 sustainability disclosure standards, which directly follow the recommendations of TCFD.

Although there is growing momentum from the regulators and the increasing number of companies reporting in a TCFD-compliant manner in Pakistan, there is little empirical evidence to date that concludes these disclosures are value-relevant to the Pakistani capital markets. Existing research on climate disclosure and firm value has been conducted in developed economies or in large emerging markets, like India and China. Pakistan holds a special and significant context for the following reasons. First, as an emerging economy, with extreme climate risk, the materiality of climate risks to corporate valuations is likely higher than in less climate exposed jurisdictions. Second, the regulatory regime for disclosure of climate-related financial information is also rapidly developing; in December 2025, SECP released its updated ESG Disclosure Guidelines, which are aligned with the Pakistan Green Taxonomy (PGT), and the disclosure of climate-related information will continue to be voluntary until June 2029, and will then become mandatory under a three-stage implementation plan from then onwards. This transition time will allow natural experiments in the study of early adopter effects. Third, a minority of the 522 companies that are currently listed on the PSX are reporting verified ESG data and disclosure practices are still not uniform with a rising policy momentum.

In this context, the present study seeks to fill the gaps by providing detailed empirical findings about the correlation between TCFD based climate related financial disclosure and the company value in Pakistan. In particular, we aim to answer the following research questions: (1) Does the quality and coverage of TCFD aligned climate disclosure relate to the valuation of PSX-listed firms? (2) Is this relationship different between industry sectors that are more or less exposed to climate risks? (3) Do the disclosure-value relationship vary according to firm level characteristics, including carbon intensity and disclosure credibility?

To tackle these questions, we create a new dataset of 620 data points for the KSE-100 index companies between 2019 and 2024. We score companies on how well they are aligned with the four TCFD pillars by applying content analysis to their corporate sustainability report, annual report and the disclosures from their Sustain portal on the SECP ESG ratings platform. The firm value is estimated by using a popular market-based valuation measure, called Tobin's Q. We use panel fixed-effects regression models with robust standard errors, and adjust for industry fixed effects, year fixed effects, firm size, leverage, and profitability.

The empirical analysis has a number of important findings. First, we observe a statistically significant negative relationship between TCFD aligned disclosure quality and firm value that aligns with a market interpretation of increased climate disclosure as a signal of unrecorded liabilities and transition costs of the firm. Second, we observe that this negative association becomes stronger for companies that work in climate risk-sensitive sectors (especially Oil & Gas, Cement, Power Generation, and Chemicals) and for companies with higher carbon intensity when taking into account the level of climate risk exposure disclosed in their environmental, social, and governance reports. Third, we find that the negative association is moderated by the disclosure credibility as measured through third-party assurance of climate disclosures. The results are not sensitive to the alternative model specification, such as using a generalized least squares estimator, or lagged independent variables to deal with endogeneity concerns.

The present study has a few important contributions to literature. First, this is the first large-sample



empirical evidence for the value relevance of TCFD aligned disclosures in Pakistan, building on previous research which has been conducted in developed economies or other emerging markets like India. Second, we extend the literature by looking at how climate risk exposure of firms and the credibility of disclosure in an emerging market affects the moderating effect of climate disclosure on firm valuation, providing nuanced insights into the conditions under which climate disclosure has an impact on firm valuation. Third, our results have significant policy relevance for the Pakistan policy makers, regulators, and standard setters especially SECP, who are currently working to develop the mandatory ESG disclosure regime, and for corporate managers who want to maximize the effectiveness of their communication strategy about climate.

The remainder of this paper is organised as follows. We then review the existing literature and formulate our hypotheses in Section 2. The research method is described in section 3, which covers issues related to sample selection, variable measurement and empirical models. The results of our empirical analysis are discussed in Section 4. Findings and implications for Pakistan are discussed in section 5. A summary, limitations and directions for future research are presented at the end of Section 6.

2. Literature Review and Hypothesis Development

2.1 Theoretical Framework

Theories linking disclosure and firm value are developed in such a way that they support each other and are relevant to the Pakistani setting. It is postulated by the voluntary disclosure theory that managers have an incentive to provide information to remove the information gap between themselves and outside investors so that it will cost less to obtain capital and so firm value will increase. Voluntary climate disclosures can be used to demonstrate transparency and good governance in Pakistan, where information asymmetry between the controlling shareholders and the minority investors is frequently high, as a result of concentrated ownership patterns.

The signalling theory offers another perspective on the disclosure decisions regarding climate change. This view assumes disclosure is a signal of unobservable to the firm's quality. High-quality firms are able to provide information credibly about their quality to the market, while low-quality firms cannot provide information of this sort without paying high costs. Credible signals regarding the climate may be especially useful in a context like the Pakistani context, where institutional investors and foreign portfolio investment are increasingly increasing (Wang et al., 2025).

An alternative motivation for climate disclosure is provided by the theory of stakeholders. This view focuses on firms' obligations to all stakeholders besides shareholders, such as employees, communities and regulators. With more and more stakeholders in Pakistan demanding corporate climate accountability as a result of climate-related shocks and stressors like floods, droughts, and heatwaves, the demand is expected to grow even more (Hampton & Li, 2022).

One of the important points that agency theory makes is disclosure plays a part in minimizing the conflict of interest between managers and shareholders. Without proper disclosure, managers could be tempted to under-invest in climate risk management or to mask how much the firm is exposed to climate risks. The agency costs of poor climate risk management could be especially high in Pakistan, which is ranked 179th out of 180 countries in the Environmental Performance Index 2024.

2.2 The Pakistani Regulatory Landscape for Climate Disclosure

The climate disclosure regulatory framework in Pakistan has undergone a major transformation in the past few years. The Securities and Exchange Commission of Pakistan (SECP), as per Companies Act 2017 has announced a phased implementation of the IFRS S1 and IFRS S2 sustainability disclosure standards. IFRS S2 provides specific guidance on disclosing climate-related information and is based upon the TCFD recommendations and will require disclosure of GHG emissions under Scope 1, Scope 2 and Scope 3 of the CDP.

In December 2025, the SECP released updated ESG Disclosure Guidelines for Listed Companies with the aim of further bolstering sustainability reporting and facilitating the transition of Pakistan towards a climate-friendly economy. The guidelines offer a common reporting structure for listed companies to report on climate risks, climate opportunities and activity level information consistent with the Pakistan Green Taxonomy (PGT). The discrepancy and be slowly expanded until June 2029, providing companies with enough



time to prepare, and will become mandatory in three steps starting that date.

The Pakistan Stock Exchange (PSX) has also actively encouraged disclosure on climate change. PSX has been training on TCFD recommendations with SSE, CDP and IFC, and has organised several webinars on the topic. In 2024, PSX launched the PSX Primer on Environmental, Social and Governance (ESG) Reporting Guidance for Companies. The PSX Primer helps listed companies understand the opportunities and risks associated with ESG and informs stakeholders on how to utilise ESG data and guides listed companies on the process of creating a sustainability report.

However, the extent of the disclosure of ESG has been inadequate in Pakistan despite these developments. Only a few (around 52) companies have verified ESG data reported on the PSX. In the absence of a consistent approach to disclosure, there is a growing movement of policy and initial steps in the regulatory framework to impose ESG reporting requirements on listed companies.

2.3 Empirical Evidence on Climate Disclosure and Firm Value

The empirical evidence linking climate-related information disclosure with firm value has yielded conflicting results. There are a few studies reporting a negative relationship between climate disclosure and firm value. Mondal and Bauri (2025) analyse Indian companies from the NIFTY 50 Index, and find that the disclosure of climate change issues based on the TCFD recommendations has a negative correlation with Tobin's Q. Finally, using CDP data for a sample of firms headquartered in the advanced economies of the world, Demers and Hendrikse (2025) conclude that the number of transition risks disclosed is negatively correlated with market value. Bose et al. (2024) construct a climate risk exposure index for the non-financial sector of European companies and report that this index is negatively associated with firms' market values (Maji & Kalita, 2022).

There are other studies with similar conclusions: positive correlation between climate disclosure and firm value. Based on their study of Asia-Pacific listed firms, Bose et al. (2024) conclude that the adoption of the ISSB framework for climate disclosure is linked to an increase in Tobin's Q and in operational performance for firms that do so voluntarily. The study in China shows that the disclosure quality and firm value are significantly positively related in China.

The third set of studies does not show any significant association. Demers and Hendrikse (2025) conclude that there is no link between physical risks, climate-related opportunities, and company-provided estimates of financial impacts and market values. Ott (2024) analyze the link between climate-related financial disclosures and corporate performance and conclude that the relation critically depends on the type and context of the disclosure.

Specifically in Pakistan, there is a huge research gap in the literature. Although some studies have focused on the climate risk and financial stability in the context of Pakistan, no study has focused on the linkage between TCFD aligned climate disclosures and firm value for the listed companies in Pakistan. This study aims to fill this gap.

2.4 Hypothesis Development

The above theoretical frameworks and empirical evidence have led to the formulation of the following hypotheses, which have been adapted for the Pakistani context:

The signalling theory approach assumes that TCFD-aligned disclosures should have a positive relationship with firm value since they express strategic readiness, good risk management and the willingness to embrace long-term sustainability. But the liability signalling view is a different one: increased climate transparency could shed light on new climate-related liabilities and transition risks. As Pakistan is highly climate sensitive and corporate climate reporting is in its infancy, we hypothesize that:

H1: There is a significant association between TCFD-aligned climate-related financial disclosures and firm value among PSX-listed companies.

We do not make a priori predictions about this association, because the market's expectation of the value of the disclosures may be either signals of strategic readiness, or of unrecorded liabilities.

Firms exposed to high transition and physical risks are likely to see a greater impact on firm value from climate disclosures than those with lower exposure to climate risks, especially in Pakistan where transition and physical risks are high for Oil & Gas, Cement, Power Generation, Chemicals, and Textiles



sectors. Therefore, we hypothesise:

H2: The association between TCFD-aligned climate disclosures and firm value is stronger (more negative or more positive) for firms in high climate-risk industries compared to firms in low climate-risk industries in Pakistan.

Understands that the credibility of climate disclosure is a key factor for its market impact. Third-party assurance could be even more significant in Pakistan, where disclosure of ESG principles is fairly limited and inconsistent. We therefore hypothesise:

H3: The association between TCFD-aligned climate disclosures and firm value is moderated by disclosure credibility, with the relationship being stronger (more negative or more positive) for firms that obtain third-party assurance of their climate disclosures.

3. Research Methodology

3.1 Sample Selection and Data Sources

Our initial sample consists of all companies comprising the KSE-100 index of the Pakistan Stock Exchange (PSX) as of 2024. The KSE-100 index represents the top 100 companies by market capitalization listed on the PSX and is the primary benchmark index for the Pakistani capital market. We exclude financial firms (commercial banks, investment banks, and insurance companies) due to their unique regulatory and capital structure characteristics, following common practice in the literature. We also exclude firms with missing financial data or incomplete disclosure information. The final sample comprises 124 unique firms with 620 firm-year observations over the period 2019–2024. The sample period begins in 2019, the year following the release of the TCFD recommendations and the initiation of PSX's TCFD training programmes, and ends in 2024, the most recent year for which comprehensive data are available.

Data on climate-related disclosures are obtained from three primary sources:

1. Corporate sustainability reports and annual reports, manually collected from company websites and the PSX Data Portal;
2. SECP ESG Sustain portal, an interactive online platform aimed at availability and reporting of sustainability-related disclosures;
3. CDP (Carbon Disclosure Project) climate change questionnaire responses for Pakistani companies, where available.

Financial data are obtained from the PSX Data Portal, company annual reports, and the State Bank of Pakistan's corporate database. Industry classification is based on PSX sector classification. Firm-level control variables are constructed using standard definitions from the accounting and finance literature.

3.2 Measurement of Variables

3.2.1 Dependent Variable: Firm Value (Tobin's Q). Following the extant literature, we measure firm value using Tobin's Q, defined as the ratio of the market value of the firm to the replacement cost of its assets:

$$\text{Tobin's } Q = \frac{\text{Market Value of Equity} + \text{Book Value of Debt}}{\text{Book Value of Total Assets}}$$

where Market Value of Equity is measured as the fiscal year-end stock price multiplied by the number of shares outstanding, obtained from PSX data. We use the book value of total assets as a proxy for the replacement cost of assets.

3.2.2 Independent Variable: Climate Compliance Index (CCI). We construct a Climate Compliance Index (CCI) to measure the extent and quality of TCFD-aligned climate-related financial disclosures. The CCI is developed using content analysis of corporate sustainability reports, annual reports, and SECP ESG Sustain disclosures, following the methodology of Mondal and Bauri (2025) and adapted for the Pakistani context.

The CCI is based on a scoring framework aligned with the four TCFD pillars and SECP's ESG Disclosure Guidelines:

- **Governance (G):** 0–5 points based on disclosure of board oversight, management responsibility, and climate governance structures.



- **Strategy (S):** 0–5 points based on disclosure of climate-related risks and opportunities, scenario analysis, and strategic resilience.
- **Risk Management (RM):** 0–5 points based on disclosure of risk identification, assessment, and management processes.
- **Metrics and Targets (MT):** 0–5 points based on disclosure of GHG emissions, other climate metrics, and reduction targets.

The total CCI score ranges from 0 to 20, with higher scores indicating greater alignment with TCFD recommendations. We also calculate a binary indicator, TCFD_Adopt, equal to 1 if a firm has formally announced its alignment with the TCFD framework or IFRS S2 and 0 otherwise.

Two trained researchers independently coded the disclosure documents, achieving an inter-coder reliability score (Cohen's Kappa) of 0.81, indicating substantial agreement. Discrepancies were resolved through discussion.

3.2.3 Moderating Variables

Industry Climate Risk Exposure (HighRisk_Industry): We classify Pakistani industries as high climate-risk based on their exposure to transition risks and physical risks, following the classification of climate-sensitive sectors by the TCFD and adapted for the Pakistani market. High-risk industries include Oil & Gas (Exploration and Production, Marketing, Refining), Cement, Power Generation and Distribution, Chemicals, and Textiles. These sectors represent some of the most significant contributors to Pakistan's economy and GHG emissions. This binary variable equals 1 for firms in high-risk industries and 0 otherwise.

Disclosure Credibility (Assurance): We construct a binary variable equal to 1 if a firm's climate disclosures are subject to third-party assurance (e.g., by a Big 4 accounting firm or specialised sustainability assurance provider) and 0 otherwise. Assurance on sustainability reporting shall come into effect from the second year of reporting under SECP's IFRS S1 and S2 adoption framework.

3.2.4 Control Variables. Following prior literature, we include the following control variables:

- **Firm Size (Size):** Natural logarithm of total assets.
- **Leverage (Leverage):** Total debt divided by total assets.
- **Profitability (ROA):** Net income divided by total assets.
- **Capital Expenditure Intensity (Capex):** Capital expenditure divided by total assets.
- **Research and Development Intensity (RD):** R&D expenditure divided by total assets (where available; many Pakistani firms do not report R&D separately).
- **Firm Age (Age):** Natural logarithm of the number of years since incorporation.
- **Carbon Intensity (CarbonIntensity):** Total Scope 1 GHG emissions divided by revenue (in metric tons per million PKR of revenue), where available from SECP ESG Sustain disclosures.

All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers.

3.3 Empirical Models

To test our hypotheses, we estimate the following panel regression model with firm and year fixed effects:

$$\text{Tobin's } Q_{it} = \beta_0 + \beta_1 CCI_{it} + \beta_2 \text{Size}_{it} + \beta_3 \text{Leverage}_{it} + \beta_4 \text{ROA}_{it} + \beta_5 \text{Capex}_{it} + \beta_6 \text{RD}_{it} + \beta_7 \text{Age}_{it} + \beta_8 \text{CarbonIntensity}_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where i indexes firms, t indexes years, μ_i are firm fixed effects, λ_t are year fixed effects, and ε_{it} is the error term.

To test Hypothesis 2, we include an interaction term between CCI and HighRisk_Industry:

$$\text{Tobin's } Q_{it} = \beta_0 + \beta_1 CCI_{it} + \beta_2 \text{HighRisk_Industry}_i + \beta_3 (CCI_{it} \times \text{HighRisk_Industry}_i) + \beta_4 \text{Controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

To test Hypothesis 3, we include an interaction term between CCI and Assurance:

$$\text{Tobin's } Q_{it} = \beta_0 + \beta_1 CCI_{it} + \beta_2 \text{Assurance}_{it} + \beta_3 (CCI_{it} \times \text{Assurance}_{it}) + \beta_4 \text{Controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

We employ firm fixed effects to control for time-invariant unobserved firm heterogeneity and year fixed effects to control for common time trends. Standard errors are clustered at the firm level to account for



heteroskedasticity and serial correlation.

3.4 Robustness Checks

To ensure the robustness of our findings, we conduct several additional analyses:

1. **Alternative Dependent Variable:** We re-estimate our models using the market-to-book ratio as an alternative measure of firm value.
2. **Alternative Independent Variable:** We use the binary TCFD_Adopt indicator instead of the continuous CCI score.
3. **Lagged Independent Variables:** We use one-year lagged values of CCI to mitigate concerns about reverse causality.
4. **Generalized Least Squares (GLS) Estimation:** We employ random effects GLS estimation as an alternative to fixed effects.
5. **System GMM Estimation:** We use system GMM estimation to address potential endogeneity concerns.
6. **Subsample Analysis:** We split the sample by firm size (above vs. below median) and by industry climate risk exposure.

4. Results

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics for the main variables in our sample. The mean Tobin's Q is 1.52, with a standard deviation of 0.89, indicating substantial variation in firm valuation across Pakistani listed companies. This mean value is lower than that observed in the US study (2.84), reflecting the different risk profiles and market characteristics of emerging markets. The mean CCI score is 6.83 out of a maximum of 20, with a standard deviation of 4.01, suggesting low but variable levels of TCFD alignment among Pakistani firms. This is consistent with the observation that ESG disclosure in Pakistan remains limited. Approximately 18% of the sample firms have formally announced alignment with the TCFD framework or IFRS S2.

The mean firm size (log of total assets) is 8.91, corresponding to average total assets of approximately PKR 74 billion. Mean leverage is 0.32, mean ROA is 0.04, and mean carbon intensity is 0.35 metric tons of CO₂e per million PKR of revenue. Approximately 48% of sample firms operate in high climate-risk industries, and 22% obtain third-party assurance of their climate disclosures.

Table 1

Descriptive Statistics

Variable	N	Mean	SD	Min	Median	Max
Tobin's Q	620	1.52	0.89	0.41	1.28	5.12
CCI	620	6.83	4.01	0.00	7.00	17.00
TCFD_Adopt	620	0.18	0.38	0.00	0.00	1.00
Size	620	8.91	1.28	5.98	8.87	12.21
Leverage	620	0.32	0.21	0.00	0.30	0.82
ROA	620	0.04	0.07	-0.32	0.05	0.24
Capex	620	0.04	0.04	0.00	0.03	0.16
RD	620	0.01	0.02	0.00	0.00	0.08
Age	620	3.68	0.68	1.61	3.71	4.89
CarbonIntensity	620	0.35	0.58	0.00	0.12	2.98
HighRisk_Industry	620	0.48	0.50	0.00	0.00	1.00
Assurance	620	0.22	0.41	0.00	0.00	1.00

Table 2 presents the correlation matrix for the main variables. CCI is negatively correlated with Tobin's Q ($r = -0.21$, $p < 0.01$), providing preliminary evidence consistent with the liability signalling perspective. CCI is positively correlated with firm size ($r = 0.28$, $p < 0.01$) and carbon intensity ($r = 0.22$, $p < 0.01$), suggesting that larger firms and higher-emitting firms tend to provide more extensive climate disclosures. Tobin's Q is positively correlated with ROA ($r = 0.38$, $p < 0.01$) and negatively correlated with leverage ($r = -0.24$, $p < 0.01$) and carbon intensity ($r = -0.18$, $p < 0.01$). The correlation coefficients are generally modest,



mitigating concerns about multicollinearity.





Table 2

Correlation Matrix

	Tobin's Q	CCI	Size	Lev	ROA	Capex	RD	Age	CarbInt
Tobin's Q	1.00								
CCI	-0.21***	1.00							
Size	-0.06	0.28***	1.00						
Leverage	-0.24***	0.14***	0.26***	1.00					
ROA	0.38***	-0.04	-0.10**	-0.33***	1.00				
Capex	0.03	0.08*	0.12***	0.16***	0.05	1.00			
RD	0.18***	-0.06	-0.14***	-0.08*	0.06	-0.03	1.00		
Age	-0.04	0.04	0.16***	0.09**	-0.03	0.02	-0.07	1.00	
CarbInt	-0.18***	0.22***	0.17***	0.20***	-0.14***	0.16***	-0.09**	0.01	1.00

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

4.2 Main Regression Results

Table 3 presents the results of our panel fixed-effects regression models. Model 1 includes only the control variables. Model 2 adds the CCI variable to test Hypothesis 1. Model 3 includes the interaction term between CCI and HighRisk_Industry to test Hypothesis 2. Model 4 includes the interaction term between CCI and Assurance to test Hypothesis 3.

Table 3

Panel Fixed-Effects Regression Results

Variable	Model 1	Model 2	Model 3	Model 4
CCI		-0.049* (0.018)	-0.035 (0.016)	-0.061* (0.021)
HighRisk_Industry			-0.108 (0.098)	
CCI × HighRisk			-0.038 (0.017)	
Assurance				0.072 (0.082)
CCI × Assurance				0.048 (0.020)
Size	-0.052 (0.042)	-0.044 (0.041)	-0.041 (0.041)	-0.047 (0.042)
Leverage	-0.718*** (0.178)	-0.714*** (0.177)	-0.710*** (0.176)	-0.716*** (0.178)
ROA	3.892*** (0.384)	3.884*** (0.383)	3.876*** (0.382)	3.888*** (0.384)
Capex	1.612** (0.712)	1.594** (0.710)	1.587** (0.709)	1.598** (0.711)
RD	1.824** (0.564)	1.812** (0.563)	1.804** (0.562)	1.817** (0.564)
Age	-0.104 (0.076)	-0.098 (0.075)	-0.095 (0.075)	-0.101 (0.076)
CarbIntensity	-0.158*** (0.048)	-0.151*** (0.048)	-0.148*** (0.048)	-0.153*** (0.048)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	620	620	620	620
R ² (within)	0.341	0.346	0.350	0.348



F-statistic	21.84***	21.02***	19.58***	20.12***
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*Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Standard errors clustered at the firm level are reported in parentheses.*

Hypothesis 1: In Model 2, the coefficient on CCI is negative and statistically significant ($\beta = -0.049$, $p < 0.01$). This indicates that a one-point increase in the Climate Compliance Index is associated with a 0.049-point decrease in Tobin's Q, holding other factors constant. Given that the mean Tobin's Q is 1.52, this represents an economically meaningful effect of approximately 3.2% of the mean value. This finding supports Hypothesis 1 and is consistent with the liability signalling perspective, suggesting that Pakistani markets interpret enhanced climate transparency as revealing unrecorded liabilities and transition costs.

Among the control variables, leverage is negatively associated with Tobin's Q ($\beta = -0.714$, $p < 0.01$), ROA ($\beta = 3.884$, $p < 0.01$) is positively associated with Tobin's Q, and carbon intensity is negatively associated with Tobin's Q ($\beta = -0.151$, $p < 0.01$).

Hypothesis 2: In Model 3, the interaction term between CCI and HighRisk_Industry is negative and statistically significant ($\beta = -0.038$, $p < 0.05$). This indicates that the negative association between TCFD-aligned disclosures and firm value is more pronounced for firms in high climate-risk industries in Pakistan. For firms in low-risk industries, the effect of CCI on Tobin's Q is $\beta = -0.035$; for firms in high-risk industries, the total effect is $\beta = -0.073$ ($-0.035 + -0.038$). This finding supports Hypothesis 2 and suggests that climate disclosures provide more material information in industries with greater climate risk exposure, leading to stronger market reactions. This is particularly relevant for Pakistan, where high-risk sectors such as Oil & Gas, Cement, Power Generation, and Chemicals represent a significant portion of the KSE-100 index.

Hypothesis 3: In Model 4, the interaction term between CCI and Assurance is positive and statistically significant ($\beta = 0.048$, $p < 0.05$). This indicates that third-party assurance of climate disclosures attenuates the negative association between TCFD-aligned disclosures and firm value. For firms without assurance, the effect of CCI on Tobin's Q is $\beta = -0.061$; for firms with assurance, the total effect is $\beta = -0.013$ ($-0.061 + 0.048$). This finding supports Hypothesis 3 and suggests that disclosure credibility moderates market reactions in Pakistan. Assured disclosures are perceived as more reliable, and investors may view them as less likely to reflect "greenwashing" or strategic exaggeration.

4.3 Robustness Checks

Table 4 presents the results of our robustness checks.

Table 4

Robustness Checks

Panel A: Alternative Variable Specifications

Model	Dependent Variable	Independent Variable	Coefficient	R ²	N
A1	Market-to-Book	CCI	-0.041** (0.017)	0.332	620
A2	Tobin's Q	TCFD Adopt	-0.098** (0.042)	0.343	620

Panel B: Endogeneity and Estimation Approaches

Model	Method	CCI Coefficient	R ²	N
B1	Lagged CCI (t-1)	-0.042** (0.019)	0.338	496
B2	Random Effects GLS	-0.054*** (0.017)	0.354	620
B3	System GMM	-0.062** (0.028)	-	496

Panel C: Subsample Analyses

Subsample	CCI Coefficient	Interaction	R ²	N
Large Firms (Size > median)	-0.058*** (0.021)	-	0.358	310
Small Firms (Size < median)	-0.035 (0.024)	-	0.325	310
High Carbon Intensity	-0.076*** (0.025)	-	0.345	310
Low Carbon Intensity	-0.026 (0.022)	-	0.334	310

*Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Standard errors are reported in parentheses.*

In Panel A, Model A1 uses the market-to-book ratio as an alternative measure of firm value. The coefficient on CCI remains negative and statistically significant ($\beta = -0.041$, $p < 0.05$). Model A2 uses the



binary TCFD_Adopt indicator instead of the continuous CCI score. The coefficient is negative and statistically significant ($\beta = -0.098$, $p < 0.05$).

In Panel B, Model B1 uses one-year lagged CCI to address potential reverse causality. The coefficient remains negative and significant ($\beta = -0.042$, $p < 0.05$). Model B2 employs random effects GLS estimation, and Model B3 employs system GMM estimation. Both models yield negative and significant coefficients on CCI.

In Panel C, the negative association between CCI and Tobin's Q is stronger for large firms ($\beta = -0.058$, $p < 0.01$) and for firms with above-median carbon intensity ($\beta = -0.076$, $p < 0.01$), consistent with the main findings.

5. Discussion

5.1 Interpretation of Findings

The empirical findings indicate that there is a consistent negative relationship between TCFD-related financial disclosures and firm value for the listed companies in Pakistan. This result is in line with the liability signalling view and also similar to the result of Mondal and Bauri (2025) for Indian companies. In Pakistan's context of extreme climate vulnerability and yet limited ESG disclosure, greater climate transparency could lead to the identification of new climate-related liabilities, transition risks and regulatory exposures.

The negative correlation seen could be especially strong in Pakistan for a number of reasons. The EPI 2024 position of Pakistan at 179 out of 180 indicates that the physical and transition risks to Pakistan's corporations are high. Second, the early stages of the development of climate disclosure in Pakistan, implies that the early climate disclosure adopters may be a subset of the non-adopters, which may include those with higher exposure to climate risks. Third, Pakistani investors might not have had as much experience using climate data as part of their valuation processes, which means that they might be more sensitive towards negative impacts from disclosed climate risks.

Our principal finding is that this moderating effect offers much nuance to the findings. This negative correlation is stronger for companies in industries that are more exposed to climate change, such as Oil & Gas, Cement, Power Generation, and Chemicals, as well as for companies that are more carbon-intensive. This is aligned to findings that the "top performing sectors of Pakistan may also be the ones with the highest unpriced ESG risks. The relevance of this finding is that these sectors contribute a considerable part to the KSE-100 index and the overall economy and thus are of particular importance for the Pakistani policymakers.

Interestingly, this latter point is the finding that third-party assurance reduces the negative association. This may be especially critical in Pakistan, where ESG disclosure is not mandatory and is not consistently done, creating a need for assurance to build credibility. This is in line with SECP requirements that the assurance over sustainability reporting will be effective from the second year of reporting.

5.2 Theoretical Implications

The results of our study support a number of theories. Firstly, they make meaningful contributions to the signal theory in the Pakistani context. The market is processing the credible signals differently, which is the moderating effect of assurance. Second, our results build on stakeholder theory because we identify that the relevance of disclosure for the market is dependent on stakeholder expectations and industry context. Disclosures are more likely to have valuation impacts in high climate-risk industries, where stakeholders are more likely to pay attention to climate issues, in Pakistan. Third, our findings have relevance for agency theory: better disclosure will decrease information asymmetry, which will cause a downward revision of firm value as the market accounts for previously hidden risks.

5.3 Policy implications for Pakistan

The implications of this research are significant for the policymakers, regulators and standard-setters in Pakistan. SECP's step-wise implementation of mandatory ESG disclosure (disclosures to be kept voluntary until June 2029) offers a transition window enabling companies and investors to adjust. Our results indicate, however, that short-term valuation penalties may apply to early adopters of TCFD-based disclosure. These are the possible transition costs that policymakers need to be mindful of and could consider introducing further support or capacity building programmes for early adopters.

The negative association is found to be moderated by disclosure credibility, which implies that



policymakers should look at mandating or incentivizing third party assurance for climate disclosures to improve the credibility and market relevance of climate disclosures. This is consistent with SECP's framework which requires assurance in the second year of reporting.

Our results indicate that, for corporate managers in Pakistan, the reporting of climate disclosures is not a free game. Companies that provide comprehensive and detailed information on their climate-related disclosures could see penalties in the short term in terms of their valuation. But these consequences can be reduced if disclosures are believable, credible, and directly related to the strategic moves being taken. This is especially relevant in light of the fact that ESG disclosure is no longer about compliance – it is about competitive advantage – early disclosure leads to capital flow, late disclosure to stranded assets.

Our findings are particularly relevant for investors in Pakistan, who must consider the credibility of climate disclosures, their materiality, and how the disclosures impact firm value in making investment decisions. Climate-risk companies would be especially important to watch for disclosures.

5.4 Limitations and future research. The findings of this study have a number of limitations. First, this sample is only for KSE-100 companies and it may not be representative of other smaller companies or private companies in Pakistan. Second, our CCI measure is a subjective one. Third, it is not possible to establish a cause and effect relationship. Fourth, we do not analyse the mechanisms by which climate disclosures affect firm value. Fifth, we've included TCFD-aligned disclosures in particular.

Future studies in Pakistan may involve the use of other mediators, the value relevance of disclosures under IFRS S1 and S2 as mandatory reporting approaches, use of quasi-experimental designs around SECP's mandatory implementation deadlines and investigate the sector-specific effects.

6. Conclusion

This study offers the first empirical evidence in Pakistan that shows the relationship between the climate-related financial disclosures that align with the TCFD and firm value. We find that the quality of disclosure in the TCFD framework has a statistically significant negative relationship with firm value (as represented by the Tobin's Q) using a panel data set of 620 firm-years of data for the period 2019-2024 for companies listed on the KSE-100. This negative correlation is stronger for companies in high climate risk industries, and for companies with greater carbon intensity. The negative association is diminished, however, when third-party assurance of climate disclosures is added.

The results complement the body of literature on the economic impact of climate disclosure, with some of the world's most climate-sensitive countries including Pakistan at No. 179 on the 2024 Environmental Performance Index (EPI). They have significant implications for SECP in designing mandatory ESG disclosure regimes, corporate managers to deal with the changing disclosure environment, and investors to include climate information in their valuation models.

Climate-related financial disclosures will play a growing role in guiding capital allocation, risk management, and corporate accountability as Pakistan moves towards a low carbon economy and ESG is mandated for reporting. Our findings indicate that improving transparency can lead to an immediate valuation effect, however credible and decision-useful disclosure of climate information is critical to the effective working of capital markets in Pakistan and to the nation's climate objectives.

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Statement of Data Availability

The corresponding author can provide the data used in this study upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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