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Research article

Green banking in transition: ESG disclosure, credit risk governance, and firm value in an institutionally diverse Asia-Pacific dataset

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Abstract: In this study, we investigated the relationship between Environmental, Social, and Governance (ESG) disclosure and firm value in the Asia-Pacific banking sector, based on panel data from 249 publicly listed banks across 18 countries over the period 2009–2023. Under increasing regulatory and market pressures, ESG transparency is often adopted without sufficient internal risk governance, raising concerns of symbolic compliance and greenwashing. To address this gap, we introduced Credit-based Loan Loss Provision (CLLP) as a novel mediating mechanism that captures the integration of ESG into prudential credit risk management. Using a fixed-effects panel regression and a two-stage least squares (2SLS) approach, our findings revealed that ESG disclosure exerts a significantly negative direct effect on firm value, as measured by Tobin's Q, particularly in the absence of credible risk governance. However, when mediated by CLLP, ESG disclosure, across environmental disclosure scores (EDS), social disclosure scores (SDS), and governance disclosure scores (GDS) dimensions, positively and significantly influences firm value. Moreover, a nonlinear analysis revealed an inverted U-shaped relationship, indicating that while moderate ESG disclosure enhances firm value, excessive disclosure may reduce it. These results underscore the importance of aligning ESG reporting with internal risk controls to ensure credibility and market value. The study contributes to the theoretical discourse by reinforcing stakeholder, signaling, legitimacy, and resource-based view perspectives. It offers practical implications for regulators and banking institutions aiming to enhance the quality of ESG disclosure and its integration into risk-based frameworks for sustainable finance.

Keywords: Asia-Pacific; credit-based loan loss provision; ESG disclosure; green banking; prudential credit; sustainable finance

JEL Codes: G21, G32, M14, Q56

1. Introduction

The transformation toward a sustainable financial system has become a strategic imperative in response to escalating global risks, climate-related crises, and mounting demands for transparency and accountability across jurisdictions (Carè et al., 2024). Within this evolving landscape, the banking sector plays a central role by adopting green banking practices, which are increasingly anchored in Environmental, Social, and Governance (ESG) principles integrated into governance frameworks and credit allocation policies (Migliorelli & Dessertine, 2020).

A growing number of global initiatives, such as the Principles for Responsible Banking (UNEP FI, 2024), the Sustainable Finance Disclosure Regulation (SFDR) (European Commission, 2019), and the TCFD Recommendations (Financial Stability Board, 2017), have encouraged the systematic incorporation of sustainability considerations into bank risk management systems. These frameworks aim to ensure that ESG disclosure is not merely a reporting exercise but is internalized into core financial decision-making processes.

However, the actual impact of ESG disclosure on firm value, particularly in the banking sector, remains a subject of scholarly debate (Bătae et al., 2021; Singhania & Gupta, 2024). While ESG transparency is often assumed to improve market valuation and stakeholder confidence, empirical findings reveal that such disclosure may produce adverse outcomes when perceived as symbolic, non-substantive, or overly compliance-driven (Bancu, 2024; Hao et al., 2025). These unintended consequences are particularly evident when ESG disclosure is not reinforced by credible internal governance mechanisms, which undermines its signaling effect and raises investor skepticism (Delmas & Burbano, 2011; Fatemi et al., 2018).

This challenge is particularly salient in the Asia-Pacific region, where institutional diversity is pronounced and multidimensional (Gunarathne et al., 2021). While developed economies in the region have established relatively mature ESG frameworks, many developing countries face persistent obstacles such as weak regulatory infrastructure, low sustainability literacy, and fragmented reporting practices (Pasamar et al., 2023). Consequently, ESG disclosure practices vary significantly across countries, necessitating a cross-country analytical approach to understand how ESG functions within overlapping and often conflicting institutional environments (Marquis & Qian, 2014).

Researchers have tended to classify countries based on binary distinctions, developed versus developing, when evaluating ESG dynamics (Cantero-Saiz et al., 2025). However, this approach overlooks the growing trend toward cross-border banking and regional convergence in sustainability strategies (Avci & Sungu-Esen, 2022; Gunarathne et al., 2021). Recognizing this gap, we employed a combined panel dataset comprising 249 publicly listed banks from 18 Asia-Pacific countries to analyze ESG disclosure behavior in the context of institutional integration.

Moreover, although the ESG–firm value nexus has received considerable attention, relatively few researchers have simultaneously considered ESG disclosure and internal risk governance as interdependent mechanisms. In particular, the mediating role of prudential indicators, such as credit risk provisioning, remains underexplored (Atif & Ali, 2021; Ding et al., 2024; Salem et al., 2024; Singhania & Gupta, 2024). Most researchers have emphasized direct linear relationships without examining how internal managerial practices can reinforce or dilute the effects of ESG signaling.

To address this research gap, we introduce Credit-based Loan Loss Provision (CLLP) as a novel mediating variable. Unlike traditional prudential indicators such as Non-Performing Loans (NPLs), Loan Loss Reserves (LLR), or the Capital Adequacy Ratio (CAR), which are predominantly backward-looking or static, CLLP reflects the forward-looking alignment between credit expansion and provisioning discipline. In this way, CLLP operationalizes a bank's proactive prudential governance capacity, making it a more dynamic signal of credit resilience and ESG internalization.

By positioning CLLP as a mediator, we sharpen the theoretical contribution: ESG disclosure in isolation may not always enhance firm value, but when reinforced by strong prudential governance (proxied by CLLP), it can improve market valuation by signaling disciplined risk management. ESG disclosure that is reinforced by robust risk provisioning is expected to produce greater market value than disclosure that is merely symbolic or operationally fragmented (Chairani & Siregar, 2021; Eriandani & Winarno, 2024; Helfaya et al., 2023; Krasodomska & Eisenschmidt, 2025).

Using panel data econometrics and a two-stage least squares (2SLS) estimation strategy, we empirically examine how environmental disclosure scores (EDS), social disclosure scores (SDS), governance disclosure scores (GDS), and aggregate ESG scores influence firm value, as measured by Tobin's Q, through the mediating role of CLLP. By utilizing a cross-country Asia-Pacific dataset, the analysis extends beyond the conventional developed–developing dichotomy and instead engages with the region's institutional complexity and convergence trends.

The contributions of this study are twofold. Theoretically, it integrates insights primarily from signaling theory and stakeholder theory while adopting the resource-based view (RBV) as a complementary lens. This framework emphasizes signaling credibility and stakeholder legitimacy as the dominant mechanisms, with RBV enriching the explanation by framing CLLP as a tacit, inimitable managerial capability. Practically, it offers actionable implications for regulators and bank management seeking to harmonize ESG disclosure with prudential standards, thereby aligning sustainability initiatives with financial stability imperatives in institutionally diverse markets.

2. Literature review and hypothesis development

2.1. Theoretical perspectives on ESG disclosure

ESG disclosure has emerged as a pivotal strategy for promoting corporate sustainability and enhancing long-term risk management (Aydoğmuş et al., 2022; Duan et al., 2025; Liu, 2024). This study draws upon three foundational theoretical perspectives to conceptualize the role of ESG in the banking sector.

Stakeholder Theory (Freeman, 1984) posits that firms disclose ESG information to meet the legitimacy expectations of diverse stakeholders, including regulators, investors, and civil society. Such disclosures serve to reinforce organizational accountability and social license to operate.

Signaling Theory (Spence, 1973) interprets ESG disclosure as a mechanism through which firms convey information about managerial quality, risk management capability, and long-term strategic vision. In this context, ESG transparency is expected to reduce information asymmetry and shape investor perceptions of firm reliability. This study argues that in banking, ESG disclosure alone may be insufficient; it must be supported by prudential indicators such as CLLP to enhance credibility and avoid being dismissed as symbolic.

The Resource-Based View (RBV) (Barney, 1991) considers ESG capabilities as intangible strategic assets, often complex, path-dependent, and difficult to replicate, that can generate sustainable competitive advantages. In this study, RBV is adopted as a complementary lens. While signaling and stakeholder theories serve as the primary anchors, RBV enriches the framework by positioning CLLP as an embedded managerial capability that strengthens the strategic value of ESG disclosure.

Despite these normative expectations, ESG disclosure is vulnerable to becoming symbolic or decoupled from actual managerial practices. In the absence of credible internal governance structures, firms may use ESG as a tool for pseudo-legitimacy or greenwashing, aimed more at reputation management than substantive transformation (Delmas & Burbano, 2011; Testa et al., 2018; Xiao et al., 2022). This decoupling undermines the credibility of ESG signals and may lead to investor skepticism or market penalization.

As emphasized by Fatemi et al., (2018), ESG assessments must go beyond disclosure quantity and evaluate the extent to which ESG is embedded within the firm's risk governance framework. Accordingly, this study highlights prudential governance, particularly CLLP, as a critical bridge that links external disclosure to internal resilience.

2.2. CLLP as a prudential mediation mechanism

In this study, we introduce CLLP as a mediating mechanism that reflects the integration of ESG considerations into a bank's credit risk governance. CLLP is calculated as the ratio of total credit to loan loss provisions, capturing the institution's ability to balance credit expansion with risk containment. A higher CLLP suggests aggressive credit growth relative to provisioning, while a lower CLLP implies conservative risk-buffering behavior.

Unlike conventional indicators such as Non-Performing Loans (NPL), which are reactive and only reflect deteriorating asset quality after problems have emerged (Boudriga et al., 2009), or the Capital Adequacy Ratio (CAR), which functions at a macroprudential level (Nguyen, 2025), CLLP serves as a forward-looking (ex-ante) signal of credit risk management quality. In this respect, CLLP goes beyond traditional measures by aligning provisioning behavior with sustainability disclosure, thereby operationalizing ESG internalization within risk-sensitive banking functions.

From the perspective of Signaling Theory, CLLP enhances the credibility of ESG disclosure by signaling that sustainability initiatives are underpinned by sound risk governance. From the Resource-Based View (RBV), CLLP represents an internal capability, rooted in managerial judgment and prudential discipline, that is difficult for competitors to imitate and thus serves as a source of competitive advantage. From a stakeholder theory perspective, CLLP also reinforces legitimacy, as it demonstrates to regulators, depositors, and investors that ESG commitments are backed by tangible prudential practices.

While prior evidence has shown mixed results regarding the direct effect of CLLP on firm value, we emphasize its role as a mediating construct. CLLP provides conceptual leverage to explain why ESG disclosure alone may fail to affect valuation unless supported by credible credit governance practices.

To clarify the distinct characteristics of CLLP relative to more established prudential indicators, Table 1 presents a theoretical comparison of CLLP, NPL, and CAR within the context of ESG risk mediation.

Table 1. Theoretical comparison among CLLP, NPL, and CAR in the context of ESG risk mediation.

Aspect	CLLP (Credit-based Loan Loss Provision)	NPL (Non-Performing Loans)	CAR (Capital Adequacy Ratio)
Definition	Total Credit (loans outstanding) divided by Loan Loss Provision	Proportion of non-performing loans to total loans	Capital ratio to risk-weighted assets
Timing of Recognition	Proactive (anticipatory/ex-ante)	Reactive (post-factum)	Reactive with partial preventive function
Theoretical Function	Signals expected credit risk management discipline	Indicator of deteriorating asset quality	Indicator of capital resilience against general risks
Relevance to ESG	High – reflects ESG internalization within risk management practices	Low – not directly linked to ESG	Medium – general; not ESG-specific
Suitability for ESG Mediation	High — directly linked to ESG-sensitive credit and risk management	Low – captures final impacts, not preventive measures	Medium – measures general resilience, not ESG focus
Effectiveness as Market Signal	High — proactive signal of readiness to manage ESG risks	Low – suggests risk management failure	Medium – signals solvency but lacks ESG specificity

Source: Authors' compilation based on Basel Committee, (2022), Bruno et al., (2024), Jiraporn et al., (2014), and Ozili, (2023).

2.3. Tobin's Q as a proxy for firm value

Tobin's Q is widely used in the financial literature as a forward-looking indicator of firm value. It captures the ratio between a firm's market valuation and the replacement cost of its assets, thereby reflecting investor expectations about the firm's future profitability and growth potential. Compared to accounting-based measures, such as Return on Assets (ROA) or Return on Equity (ROE), Tobin's Q is considered more sensitive to intangible factors, such as corporate governance quality, strategic positioning, and ESG performance (Butt et al., 2023; Zaleski, 2024).

In the context of ESG, Tobin's Q serves as a particularly relevant valuation proxy because it encapsulates how the market perceives the credibility and future-oriented impact of sustainability disclosures. Importantly, recent empirical studies suggest that the relationship between ESG disclosure and firm value is nonlinear in nature. Specifically, an inverted U-shaped pattern has been documented, indicating that while moderate levels of ESG disclosure may enhance firm value, excessive disclosure, particularly if perceived as symbolic or inefficient, can erode investor confidence (Agarwala et al., 2024; Teng et al., 2022).

This nonlinearity implies the existence of an optimal threshold for ESG disclosure effectiveness, beyond which the marginal benefits diminish or turn negative. Accordingly, the analytical framework incorporates linear and quadratic specifications, while ensuring that turning points are interpreted cautiously and only when they fall within the observed data range.

2.4. Hypothesis development

Integrating the preceding theoretical perspectives, the following hypotheses are developed to examine the ESG–value relationship in banking.

First, while ESG disclosure is often assumed to enhance market valuation, prior research suggests that such effects may not always be positive, especially when ESG practices are symbolic or weakly institutionalized (Delmas & Burbano, 2011; Fatemi et al., 2018). This leads to the expectation that, in

the absence of robust internal risk governance, ESG disclosure may have a neutral or even negative association with firm value.

- H1a–H1d: ESG disclosure, measured by EDS, Social Disclosure Score (SDS), GDS, and ESG Total, has a negative effect on Tobin's Q in the absence of strong internal risk governance.

Second, we introduce CLLP as a mediating mechanism that captures the internalization of ESG principles within credit risk management. When ESG disclosure is supported by credible provisioning practices, it is expected to have a more favorable impact on firm value. Accordingly, the second set of hypotheses is proposed:

- H2a–H2d: CLLP mediates the relationship between each ESG dimension (EDS, SDS, GDS, and ESG Total) and Tobin's Q.

Finally, building on the literature that identifies nonlinear effects of ESG on firm performance (Agarwala et al., 2024; Teng et al., 2022), we explore the possibility that the relationship between ESG disclosure and firm value follows an inverted U-shaped pattern where moderate ESG engagement enhances value, but excessive disclosure may diminish it:

- H3: There is an inverted U-shaped relationship between ESG disclosure and firm value.

2.5. Conceptual framework

The conceptual framework (Figure 1) integrates the theoretical arguments and hypotheses developed above. ESG disclosure is expected to have direct and indirect effects on firm value, mediated by CLLP, and its impact may be nonlinear when disclosure intensity exceeds optimal thresholds.

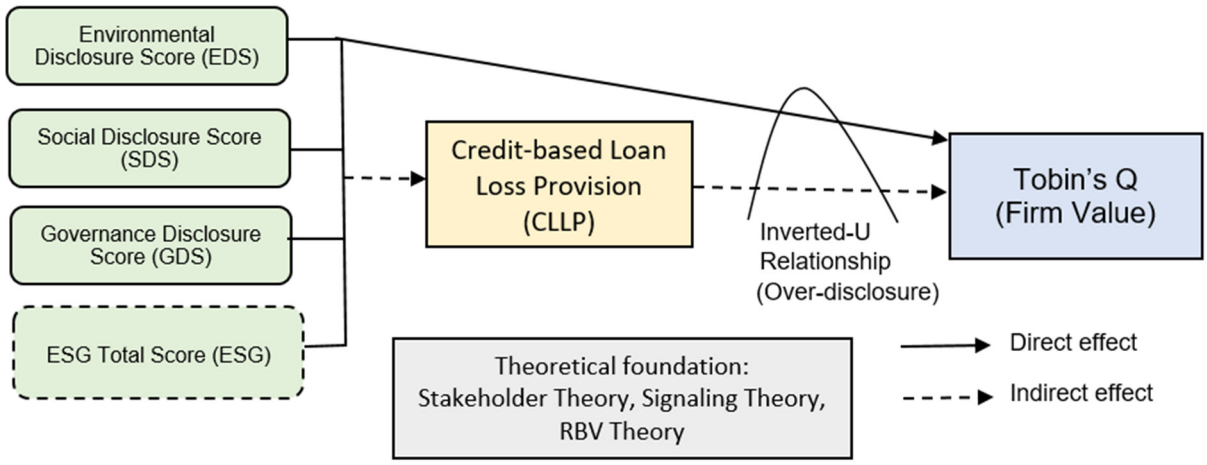

Figure 1. Conceptual Framework. This model illustrates the hypothesized relationships among ESG disclosure dimensions (EDS, SDS, GDS, and ESG Total), Credit-based Loan Loss Provision (CLLP) as a mediating variable, and firm value (Tobin's Q). The solid arrows indicate direct effects (H1a–H1d), dashed arrows indicate mediation pathways (H2a–H2d), and the curved line reflects the hypothesized inverted U-shaped relationship (H3). The framework is supported by Stakeholder Theory and Signaling Theory as primary anchors, with the Resource-Based View (RBV) serving as a complementary lens that positions CLLP as a tacit managerial capability strengthening the credibility and effectiveness of ESG disclosure.

The framework is grounded in three core theoretical perspectives:

- Stakeholder Theory (Freeman, 1984), emphasizing ESG as a tool for legitimacy and accountability;
- Signaling Theory (Spence, 1973), highlighting the role of ESG in reducing information asymmetry; and
- The Resource-Based View (RBV) (Barney, 1991), serving as a complementary perspective that positions CLLP as a tacit managerial capability that links ESG disclosure to sustainable value creation.

3. Methods

3.1. Research design

We adopt a quantitative explanatory research design with panel data to examine the relationship between ESG disclosure and firm value, with CLLP as the mediating variable. The analysis is structured to capture direct and indirect effects, as well as potential nonlinear dynamics in the ESG–value relationship.

To estimate the hypothesized relationships, a Two-Stage Least Squares (2SLS) regression model is employed. This technique addresses potential endogeneity concerns, particularly those arising from simultaneity between ESG disclosure and firm performance. In this framework, the first stage regresses each ESG dimension, EDS, SDS, GDS, and the aggregate ESG Total on CLLP to generate fitted values (CLEDS, CLSDS, CLGDS, and CLESG). The second stage then uses these fitted values to assess whether ESG internalization through CLLP aligns with the hypothesized indirect channel to firm value. This approach strengthens causal inference and provides evidence consistent with mediation while not constituting a formal mediation test in the classical sense.

In addition, a quadratic specification is incorporated to test for an inverted U-shaped relationship, capturing the possibility that moderate ESG disclosure enhances firm value, whereas excessive disclosure may yield diminishing or negative returns. Turning points are interpreted only when they fall within the observed data range; otherwise, the functional form is treated as monotonic.

This integrated methodological approach enables us to capture the complex interactions between sustainability practices, risk-based governance mechanisms, and market valuation across institutional settings. By combining endogeneity-corrected estimation, mediation analysis through CLLP, and nonlinear testing, the design aligns with recent best practices in ESG–finance research (Agarwala et al., 2024; Bruno et al., 2024).

3.2. Population, sample, and data sources

The population of this study comprises all publicly listed commercial banks in the Asia-Pacific region over the period 2009–2023. The sample is selected purposively based on two major criteria: The availability of ESG disclosure data in the Bloomberg Terminal, and the completeness of key financial variables, namely Tobin's Q, Return on Assets (ROA), Market Capitalization, and CLLP.

Following a rigorous screening process, the final dataset consists of 3,735 bank-year observations, drawn from 249 banks operating in 18 Asia-Pacific countries. ESG and financial data are primarily sourced from Bloomberg and subsequently cross-verified using firms' annual reports to ensure consistency and data integrity.

The inclusion of both developed and emerging Asia-Pacific economies ensures institutional heterogeneity, enabling the analysis to reflect differences in regulatory maturity, sustainability literacy, and market development. Table 2 summarizes the sample distribution, highlighting data completeness across countries and observation counts during the study period.

Table 2. Sample selection and distribution based on data completeness (2009–2023)

Country	Number of Banks	Incomplete Data	Complete Data	Observation Period	Number of Observations
Emerging Asia-Pacific					
Bangladesh	36	35	1	2009–2023	15
China	32	13	19	2009–2023	285
India	42	16	26	2009–2023	390
Indonesia	48	31	17	2009–2023	255
Kazakhstan	7	6	1	2009–2023	15
Malaysia	11	1	10	2009–2023	150
Pakistan	21	12	9	2009–2023	135
Papua New Guinea	1	1	0	2009–2023	0
Philippines	16	7	9	2009–2023	135
Sri Lanka	12	10	2	2009–2023	30
Thailand	12	2	10	2009–2023	150
Vietnam	27	18	9	2009–2023	135
Total Emerging Sample	265	152	113		1,695
Developed Asia-Pacific					
Australia	11	5	6	2009–2023	90
Hong Kong	33	8	25	2009–2023	375
Japan	83	6	77	2009–2023	1,155
New Zealand	1	0	1	2009–2023	15
Singapore	3	0	3	2009–2023	45
South Korea	12	6	6	2009–2023	90
Taiwan	19	1	18	2009–2023	270
Total Developed Sample	162	26	136		2,040
Total Observations	427	178	249		3,735

Note: Incomplete data refer to banks missing full ESG disclosure, credit risk metrics, or firm valuation variables during the observation period.

Source: Authors' compilation based on Bloomberg data (2024).

3.3. Variable definitions and measurements

Table 3 summarizes the operational definitions and measurement approaches for all variables used in this study, including dependent, independent, mediating, and control variables. In particular, the aggregate ESG disclosure score (ESG Total) is computed as the sum of the three Bloomberg pillar scores: EDS, SDS, and GDS. Each pillar score is standardized on a 0–100 scale, resulting in an additive ESG Total index ranging from 0 to 300. This equal-weighted summation preserves transparency across the three dimensions and is conceptually equivalent to a linear transformation of the average ESG index (i.e., ESG_sum = 3 × ESG_mean). Thus, the aggregation does not alter the substantive interpretation of ESG performance but provides a broader scale for capturing cross-sectional variation in disclosure practices. To ensure that the choice of scale does not bias empirical results, robustness checks are conducted using the average ESG index (0–100), and the major findings remain qualitatively consistent.

Table 3. Variable definitions and measurements.

Variable	Definition	Measurement
Tobin's Q	Market valuation relative to asset replacement cost	(Market Value of Equity + Book Value of Debt) / Book Value of Total Assets
EDS	Environmental Disclosure Score	Environmental Pillar Score from Bloomberg (%)
SDS	Social Disclosure Score	Social Pillar Score from Bloomberg (%)
GDS	Governance Disclosure Score	Governance Pillar Score from Bloomberg (%)
ESG Total	Aggregate ESG disclosure score	Sum of EDS, SDS, and GDS (range 0–300); robustness checks with average ESG index (0–100) confirm consistency
CLLP	Credit-based Loan Loss Provision	Total Credit (loans outstanding) / Loan Loss Provision
ROA	Profitability	Net Income / Total Assets
Ln_CMC	Firm size (Ln of market capitalization)	Natural logarithm of Market Capitalization
CLEDS	Predicted EDS effect on CLLP	Fitted value from first-stage regression (2SLS)
CLSDS	Predicted SDS effect on CLLP	Fitted value from first-stage regression (2SLS)
CLGDS	Predicted GDS effect on CLLP	Fitted value from first-stage regression (2SLS)
CLESG	Predicted ESG Total effect on CLLP	Fitted value from first-stage regression (2SLS)

Note: The mediating variables, CLEDS, CLSDS, CLGDS, and CLESG, are fitted values obtained from the first-stage regressions within the Two-Stage Least Squares (2SLS) framework. Control variables include Return on Assets (ROA) and firm size (Ln_CMC). ESG-related data were sourced from Bloomberg (2024).

3.4. Descriptive statistics and outlier treatment

Table 4. Descriptive statistics.

Variable	N	Min	Max	Mean	SD
Panel A. Before Winsorization					
EDS	2,966	0.000	81.486	12.446	15.650
SDS	2,966	0.000	76.149	18.123	14.860
GDS	2,966	14.509	98.615	69.551	15.450
ESG Total	3,563	0.000	243.289	83.344	52.589
CLLP	3,500	−3,116,512.000	12,200,000.000	1,296.594	219,027.800
ln_CMC	3,313	19.065	34.686	25.864	2.389
ROA	3,511	−12.284	11.224	0.778	0.966
Tobin's Q	3,309	0.807	21.850	1.040	0.625
CLEDS	2,966	402.552	425.445	419.167	7.642
CLSDS	2,966	272.819	510.514	419.646	70.489
CLGDS	2,966	362.847	483.596	419.522	36.680
CLESG	3,563	343.667	434.435	387.165	26.866
Panel B. After Winsorization (5% Level)					
EDS_w	2,966	0.000	44.005	12.069	14.690
SDS_w	2,966	0.000	46.191	17.658	13.698
GDS_w	2,966	44.943	91.812	69.814	14.238
ESG Total_w	3,563	0.000	172.225	82.533	50.976
CLLP_w	3,500	−2,200.029	3,369.706	387.494	1,117.699
ln_CMC_w	3,313	22.948	31.136	25.838	2.165
ROA_w	3,511	0.069	2.116	0.777	0.585
Tobin's Q_w	3,309	0.951	1.161	1.006	0.055
CLEDS	2,966	402.552	425.445	419.167	7.642
CLSDS	2,966	272.819	510.514	419.646	70.489
CLGDS	2,966	362.847	483.596	419.522	36.680
CLESG	3,563	343.667	434.435	387.165	26.866

Note: Winsorization at the 5% level was applied to reduce the impact of extreme outliers across all primary variables, with the exception of the fitted values (CLEDS, CLSDS, CLGDS, and CLESG), which are retained in their original form due to their derivation from first-stage 2SLS estimations.
Source: Authors' calculations based on STATA v.17.0 (2024).

To address the potential influence of extreme values, we apply 5% winsorization at both tails (top and bottom) for all continuous variables, with the exception of the fitted variables generated from the Two-Stage Least Squares (2SLS) procedure. Winsorization is a widely accepted method for minimizing the distortion caused by outliers without omitting observations entirely (Billor et al., 2000; Sullivan et al., 2021). The fitted values, CLEDS, CLSDS, CLGDS, and CLESG, are retained in their original form to preserve the structural properties of the first-stage regression outputs. For robustness, alternative thresholds (e.g., 1%) are also considered, and the overall patterns of results remain consistent.

Table 4 presents the descriptive statistics before and after winsorization, including measures of central tendency and dispersion for each variable.

3.5. Estimation models and analytical strategy

To rigorously test the proposed hypotheses, we adopt a multi-model estimation strategy that incorporates both causal inference and nonlinear testing. Each estimation technique is selected based on its ability to address specific econometric challenges while aligning with the theoretical foundations of the study.

1. Fixed Effects Panel Regression
   This model is employed to estimate the direct effects of ESG disclosure, namely EDS, SDS, GDS, and ESG Total, on firm value, proxied by Tobin's Q. The Fixed Effects Model (FEM) controls for unobserved time-invariant heterogeneity across banks, such as institutional culture or managerial style, which may otherwise bias the estimation results. Model specification is guided by diagnostic tests including the Chow test, Hausman test, and Breusch–Pagan LM test.
2. Two-Stage Least Squares (2SLS)
   To address potential endogeneity between ESG disclosure and firm value, arising from simultaneity, omitted variable bias, or measurement error, we apply a 2SLS estimation procedure:
   - Stage 1: Each ESG dimension is regressed on CLLP, capturing ESG disclosure as mediated through internal credit risk governance. This generates fitted values (CLEDS, CLSDS, CLGDS, and CLESG) representing ESG signals adjusted for risk discipline.
   - Stage 2: These fitted values are then regressed on Tobin's Q to test the indirect effects of ESG disclosure via prudential governance. This approach strengthens causal inference in the presence of potential simultaneity.

   Instrument strength is assessed via first-stage diagnostics (partial R^2 and first-stage F-statistics). This follows standard practice as established in Stock & Yogo, (2005) and later treatments (e.g., Windmeijer, 2025) showing that a sufficiently large first-stage F-statistic is essential to avoid weak instrument bias. Because many specifications in this study are exactly identified (one instrument per endogenous regressor), conventional overidentification statistics such as the Cragg–Donald and Kleibergen–Paap tests are not applicable (Stock & Yogo, 2005). Where over-identification arises (multiple instruments), these tests will be applied and reported.
3. Quadratic Regression Model
   To test for potential nonlinearities in the ESG–firm value relationship, a quadratic specification is applied by including ESG and ESG^2 as regressors. This enables the detection of an inverted U-shaped relationship, as suggested by prior literature (Agarwala et al., 2024; Teng et al., 2022), where moderate ESG disclosure enhances firm value but excessive disclosure may yield diminishing or negative returns. In addition, Ramsey RESET tests are performed to check for

potential model misspecification and to validate the presence of nonlinearities in the ESG–value relationship (Ramsey, 1969).

All estimations are conducted using STATA version 17.0, with robust standard errors clustered at the firm level to ensure inference validity in the presence of heteroskedasticity and serial autocorrelation (Bramati & Croux, 2007). Model robustness is further evaluated through alternative specifications and sub-sample analyses, as elaborated in the results section.

3.6. Classical assumption testing

To ensure the validity of the regression models, several classical assumption tests are conducted. The results confirm that the data are appropriate for panel regression analysis after correcting for certain violations. The key diagnostics and corrective measures are summarized below.

- Multicollinearity: All independent variables exhibit Variance Inflation Factor (VIF) values below 3, well within the accepted threshold of 5 (Thompson et al., 2017). This indicates that multicollinearity is not a concern in any of the estimated models. Detailed VIF results are presented in Table 5.

Table 5. Multicollinearity test results (Variance Inflation Factor–VIF).

Model	Variable	VIF	1/VIF
1	SDS	2.83	0.35
	EDS	2.51	0.40
	GDS	2.07	0.48
	ROA	1.30	0.77
	Ln_CMC	1.23	0.81
2	SDS	2.74	0.36
	EDS	2.43	0.41
	GDS	1.93	0.52
3	ESG Total	1.01	0.99
	ROA	1.16	0.86
	Ln_CMC	1.17	0.85
4	ESG Total	1.00	1.00
5	CLEDS	1.03	0.96
	ROA	1.17	0.85
	Ln_CMC	1.20	0.83
6	CLEDS	1.00	1.00
7	CLSDS	1.08	0.93
	ROA	1.20	0.83
	Ln_CMC	1.20	0.83
8	CLSDS	1.00	1.00
9	CLGDS	1.09	0.92
	ROA	1.26	0.79
	Ln_CMC	1.17	0.85
10	CLGDS	1.00	1.00
11	CLESG	1.01	0.99
	ROA	1.16	0.86
	Ln_CMC	1.17	0.85
12	CLESG	1.00	1.00

Note: All VIF values are below 5, indicating no multicollinearity concerns across the models. Winsorization is applied at the 5% level to all variables except the fitted values (CLEDS, CLSDS, CLGDS, and CLESG), which are derived from the first-stage regressions and retained in original form.

Source: Authors' calculations using STATA v.17.0 (2024).

- Heteroskedasticity: The Breusch–Pagan test indicates the presence of heteroskedasticity in most models (Breusch & Pagan, 1980; Halunga et al., 2017). As a corrective measure, all regressions are estimated using heteroskedasticity-robust standard errors. Test results are shown in Table 6.
- Serial Autocorrelation: The Wooldridge test for panel data detects statistically significant first-order autocorrelation across all models (Drukker, 2003; Wooldridge, 2010). To mitigate this, all estimations are conducted using robust standard errors clustered at the firm level, ensuring inference validity under serial correlation. Full test outcomes are provided in Table 7.

Table 6. Results of breusch–pagan heteroskedasticity test.

Model	Model Specification	Chi² Statistic	p-value
1	EDS, SDS, GDS → Tobin's Q (with controls)	849.61	<0.001
2	EDS, SDS, GDS → Tobin's Q (without controls)	134.14	<0.001
3	ESG Total → Tobin's Q (with controls)	898.31	<0.001
4	ESG Total → Tobin's Q (without controls)	0.86	0.355
5	CLEDS → Tobin's Q (with controls)	917.03	<0.001
6	CLEDS → Tobin's Q (without controls)	0.31	0.575
7	CLSDS → Tobin's Q (with controls)	843.61	<0.001
8	CLSDS → Tobin's Q (without controls)	25.38	<0.001
9	CLGDS → Tobin's Q (with controls)	879.97	<0.001
10	CLGDS → Tobin's Q (without controls)	89.09	<0.001
11	CLESG → Tobin's Q (with controls)	898.31	<0.001
12	CLESG → Tobin's Q (without controls)	0.86	0.355

Note: Heteroskedasticity is detected in most models (except Models 4, 6, and 12), thereby justifying the use of robust standard errors. Control variables included in relevant models are ROA and Ln_CMC. All variables are winsorized at the 5% level.

Source: Authors' calculations using STATA v.17.0 (2024).

Table 7. Wooldridge test for first-order autocorrelation in panel data.

Model	Model Specification	F-statistic	p-value
1	EDS, SDS, GDS → Tobin's Q (with controls)	47.245	<0.001
2	EDS, SDS, GDS → Tobin's Q (without controls)	62.198	<0.001
3	ESG Total → Tobin's Q (with controls)	89.652	<0.001
4	ESG Total → Tobin's Q (without controls)	107.611	<0.001
5	CLEDS → Tobin's Q (with controls)	52.149	<0.001
6	CLEDS → Tobin's Q (without controls)	65.089	<0.001
7	CLSDS → Tobin's Q (with controls)	50.806	<0.001
8	CLSDS → Tobin's Q (without controls)	64.948	<0.001
9	CLGDS → Tobin's Q (with controls)	52.746	<0.001
10	CLGDS → Tobin's Q (without controls)	64.483	<0.001
11	CLESG → Tobin's Q (with controls)	89.652	<0.001
12	CLESG → Tobin's Q (without controls)	107.611	<0.001

Note: All models exhibit significant first-order autocorrelation ($p < 0.001$), justifying the use of clustered robust standard errors at the firm level. Control variables included in relevant models are ROA and Ln_CMC. All variables are winsorized at the 5% level.

Source: Authors' calculations using STATA v.17.0 (2024).

4. Results

4.1. Linear panel regression results: ESG disclosure and tobin's Q

In this section, we present the results of the fixed effects panel regression models that test the direct impact of ESG disclosure on firm value, proxied by Tobin's Q. All four ESG dimensions, EDS, SDS, GDS, and the aggregate ESG Total score (constructed as the sum of EDS, SDS, and GDS; range 0–300), exhibit statistically significant negative effects on firm value.

These results provide empirical support for Hypotheses H1a–H1d. The negative coefficients suggest that ESG disclosure, when not supported by robust internal governance or perceived as symbolic, may undermine market confidence rather than enhance it. This aligns with research highlighting that superficial or poorly integrated sustainability reporting can trigger investor skepticism or perceptions of greenwashing. For instance, Fatemi et al. (2018) found that while ESG strengths increase firm value, ESG disclosure per se can decrease valuation, especially when it is not accompanied by substantive ESG performance, and Bancu (2024) refers to this pattern as the "ESG disclosure paradox."

To clarify measurement, EDS, SDS, and GDS are Bloomberg ESG disclosure scores scaled from 0 to 100, combining binary indicators (e.g., whether a disclosure item is reported) and ordinal assessments of disclosure quality, based on annual reports and other public filings (i.e., backward-looking). The aggregate ESG Total is obtained by summing the three dimensions with equal weights (0–300). Because equal weighting may not perfectly reflect market perceptions or banks' ESG priorities, a robustness check is conducted using the ESG Average (0–100). Importantly, the results remain negative and statistically significant across both aggregation methods, confirming that the findings are not an artifact of the weighting scheme but instead reflect the underlying disclosure–value dynamics.

The regression results, displayed in Table 8, are estimated with and without control variables, Return on Assets (ROA) and firm size (Ln_CMC), both of which are consistently significant at the 1% level, confirming their importance in explaining firm valuation.

Table 8. Linear panel regression results: ESG disclosure and firm value (Tobin's Q).

Hypothesis	Variable	With Controls	t-stat	Without Controls	t-stat
H1a	EDS	−0.0004 ***	−3.86	−0.0003 ***	−2.65
H1b	SDS	−0.0008 ***	−4.83	−0.0007 ***	−4.28
H1c	GDS	−0.0002 ***	−2.54	−0.0002 **	−2.27
H1d	ESG Total	−0.0001 ***	−7.01	−0.0001 ***	−5.99

Note: Panel regression estimates are reported both with and without control variables (Ln_CMC and ROA). All models are estimated using robust standard errors clustered at the firm level. The ESG Total variable is constructed as the sum of EDS, SDS, and GDS (0–300). A robustness check using the ESG Average (0–100) produced consistent negative and significant coefficients, reinforcing the validity of the aggregation method adopted in this study. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: Authors' computation using STATA v.17.0 (2024).

4.2. Two-stage mediation model results (2SLS): The role of CLLP

In this section, we report the results of the Two-Stage Least Squares (2SLS) estimation examining the mediating role of Credit-based Loan Loss Provision (CLLP) in the relationship between ESG disclosure and firm value. The analysis follows the standard two-stage procedure.

In the first stage, each ESG disclosure variable, EDS, SDS, GDS, and the aggregate ESG Total, is regressed on CLLP to generate fitted values (CLEDS, CLSDS, CLGDS, and CLESG). These instruments are designed to capture the extent to which ESG practices are internalized through risk provisioning. As reported in Table 9, the explanatory power in the first stage is generally weak, with low R^2 values and limited statistical significance, particularly for ESG Total. Instrument diagnostics in Table 10 confirm this pattern, as partial R^2 and robust first-stage F-statistics fall below conventional thresholds. This suggests that ESG disclosure is only weakly predictive of CLLP, raising potential weak-instrument concerns. Accordingly, the mediation results should be interpreted with caution and viewed as exploratory rather than definitive.

Table 9. First-stage 2SLS regression: Estimating fitted values of ESG disclosure on CLLP.

Model	Variable	Coefficient	Std. Error	t-statistic	p-value	R^2	Adj. R^2	N
CLEDS	EDS	−0.520	1.498	−0.35	0.728	0.000	−0.000	2,925
CLSDS	SDS	−5.146	1.611	−3.20	0.001	0.004	0.003	2,925
CLGDS	GDS	−2.576	1.555	−1.66	0.098	0.001	0.001	2,925
CLESG	ESG Total	0.527	0.371	1.42	0.156	0.001	0.000	3,500

Note: First-stage regressions of ESG disclosure indicators (EDS, SDS, GDS, and ESG Total) on CLLP. The fitted values (CLEDS, CLSDS, CLGDS, and CLESG) are subsequently used as instruments in the second-stage regressions. All variables are winsorized at the 5% level. Robust standard errors clustered at the firm level.
Source: Authors' computation using STATA v.17.0 (2024).

Table 10. First-stage instrument diagnostics.

Instrument (ESG measure)	First-stage Partial R^2	Robust F-statistic	p-value	Interpretation
EDS	0.0002	0.54	0.462	Weak instrument
SDS	0.0006	1.48	0.224	Weak instrument
GDS	0.0000	0.03	0.861	Weak instrument
ESG Total	0.0004	1.63	0.203	Weak instrument

Note: Partial R^2 and robust first-stage F-statistics are reported to assess instrument strength. Because the models are exactly identified (one instrument per endogenous variable), over-identification tests (Cragg–Donald, Kleibergen–Paap) are not applicable.
Source: Authors' computation using STATA v.17.0 (2024).

Table 11. Two-stage least squares (2SLS) second-stage estimates: Mediated effects of ESG disclosure via CLLP on firm value.

Hypothesis	Mediation Path	Model	Coefficient	t-statistic	Significance
H2a	EDS → CLLP → Tobin's Q	With Controls	0.0021	11.62	***
		Without Controls	0.0020	9.33	***
H2b	SDS → CLLP → Tobin's Q	With Controls	0.0002	10.65	***
		Without Controls	0.0002	9.30	***
H2c	GDS → CLLP → Tobin's Q	With Controls	0.0003	10.45	***
		Without Controls	0.0003	9.13	***
H2d	ESG → CLLP → Tobin's Q	With Controls	−0.0002	−7.01	***
		Without Controls	−0.0002	−5.99	***

Note: Second-stage regressions estimated with and without control variables (Ln_CMC and ROA). Robust standard errors are clustered at the firm level. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: Authors' computation using STATA v.17.0 (2024).

The second stage (Table 11) regresses the fitted values on Tobin's Q. The results indicate that CLEDS, CLSDS, and CLGDS have positive and statistically significant coefficients, consistent with Hypotheses H2a–H2c. In contrast, the aggregate ESG score (Hypothesis H2d) shows a significant negative coefficient, implying that aggregated disclosure may dilute dimension-specific signals and reduce investor confidence. Taken together, the evidence suggests that dimension-level ESG disclosure, when channeled through CLLP, strengthens market valuation, whereas aggregated ESG signals may obscure underlying risk governance quality.

4.3. Robustness checks

To address concerns regarding reverse causality, the baseline models are re-estimated using one-year lagged ESG variables. Firm value in year *t* is thus explained by ESG disclosure in year *t–1*. Table 12 reports the results for ESG dimensions (EDS, SDS, and GDS) and the aggregated ESG score, under specifications with and without controls. Panel A shows that the coefficients of lagged ESG scores remain negative and statistically significant, consistent with the major results. Panel B presents the regressions using lagged fitted values of CLLP predicted from ESG, which also exhibit the same direction and significance as the contemporaneous models. These findings indicate that the results are robust to potential reverse causality.

Table 12. Robustness checks with lagged ESG variables (t–1) and firm value (Tobin's Q).

Model	Specification	Variable	Coefficient	t-statistic	p-value	Significance	Within
Panel A. Lagged ESG Dimensions and Total							
1L	With controls	L1.EDS	–0.00031	–2.60	0.010	**	0.3645
		L1.SDS	–0.00088	–5.80	0.000	***	
		L1.GDS	–0.00019	–2.10	0.037	**	
2L	Without controls	L1.EDS	–0.00028	–1.85	0.066	*	0.1855
		L1.SDS	–0.00089	–5.28	0.000	***	
		L1.GDS	–0.00025	–2.33	0.020	**	
3L	With controls	L1.ESG Total	–0.00032	–9.34	0.000	***	0.3321
4L	Without controls	L1.ESG Total	–0.00031	–8.54	0.000	***	0.1317
Panel B. Lagged Fitted CLLP (First-Stage Predictions from ESG)							
5L	With controls	CLEDS_L1	0.00457	9.53	0.000	***	0.3122
6L	Without controls	CLEDS_L1	0.00487	8.45	0.000	***	0.1233
7L	With controls	CLSDS_L1	0.00027	10.04	0.000	***	0.3557
8L	Without controls	CLSDS_L1	0.00027	9.33	0.000	***	0.1758
9L	With controls	CLGDS_L1	0.00023	9.79	0.000	***	0.2800
10L	Without controls	CLGDS_L1	0.00027	9.37	0.000	***	0.0953
11L	With controls	CLESG_L1	–0.00059	–9.34	0.000	***	0.3321
12L	Without controls	CLESG_L1	–0.00057	–8.54	0.000	***	0.1317

Note: All models are estimated using fixed-effects panel regressions with robust standard errors clustered at the firm level. L1. indicates a one-year lag. Control variables include firm size (Ln_CMC) and profitability (ROA). Panel A tests lagged ESG scores directly, while Panel B tests lagged first-stage fitted CLLP values predicted from ESG dimensions and total. Results remain consistent in direction and significance with the contemporaneous models, confirming robustness against potential reverse causality. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: Authors' computation using STATA v.17.0 (2024).

To examine sensitivity to outliers, the baseline models are further tested using alternative winsorization thresholds at 1% and 10%, in addition to the baseline 5%. Table 13 reports the results for ESG dimensions and the aggregated ESG score, both with and without controls. Across all winsorization levels, ESG coefficients remain negative and statistically significant. These outcomes suggest that the findings are not driven by extreme values or the choice of winsorization level.

Table 13. Robustness Checks: Sensitivity to Different Winsorization Levels (1%, 5%, and 10%).

Winsor Level	Specification	Variable	Coefficient	t-statistic	p-value	Sig.	Within
Panel A. ESG Dimensions (EDS, SDS, GDS) and Firm Value (Tobin's Q)							
1%	With controls	EDS	–0.00059	–4.12	0.000	***	0.3149
		SDS	–0.00085	–3.84	0.000	***	
		GDS	–0.00026	–2.08	0.038	**	
	Without controls	EDS	–0.00047	–2.72	0.007	***	0.0745
		SDS	–0.00057	–2.27	0.024	**	
		GDS	–0.00021	–1.43	0.154	ns	
5%	With controls	EDS	–0.00047	–3.86	0.000	***	0.3491
		SDS	–0.00081	–4.83	0.000	***	
		GDS	–0.00027	–2.54	0.012	**	
	Without controls	EDS	–0.00039	–2.65	0.008	***	0.1661
		SDS	–0.00076	–4.28	0.000	***	
		GDS	–0.00028	–2.27	0.024	**	
10%	With controls	EDS	–0.00047	–4.69	0.000	***	0.3572
		SDS	–0.00074	–5.34	0.000	***	
		GDS	–0.00021	–2.36	0.019	**	
	Without controls	EDS	–0.00039	–3.29	0.001	***	0.1978
		SDS	–0.00073	–4.96	0.000	***	
		GDS	–0.00021	–2.07	0.039	**	
Panel B. ESG Total Score and Firm Value (Tobin's Q)							
1%	With controls	ESG Total	–0.00018	–5.33	0.000	***	0.2227
	Without controls	ESG Total	–0.00009	–2.52	0.012	**	0.0064
5%	With controls	ESG Total	–0.00015	–7.01	0.000	***	0.1996
	Without controls	ESG Total	–0.00013	–5.99	0.000	***	0.0270
10%	With controls	ESG Total	–0.00011	–6.76	0.000	***	0.1767
	Without controls	ESG Total	–0.00011	–6.14	0.000	***	0.0283

Note: All models are estimated using fixed-effects panel regressions with robust standard errors clustered at the firm level. Winsorization levels applied at 1%, 5% (baseline), and 10% on both tails. Control variables include firm size (Ln_CMC) and profitability (ROA) where applicable. Results indicate that coefficients for ESG dimensions and total ESG remain negative and statistically significant across winsorization thresholds, suggesting findings are not driven by outliers. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: Authors' computation using STATA v.17.0 (2024).

Overall, the robustness checks confirm that the negative association between ESG disclosure and firm value is consistent across alternative specifications, thereby strengthening the reliability of the empirical results and providing a solid basis for the subsequent discussion in Section 5.

4.4. Goodness-of-Fit assessment for direct and mediated ESG models

In this section, we evaluate the explanatory power of the regression models used to estimate the direct effects of ESG disclosure on firm value (H1a–H1d) and the indirect effects mediated by Credit-based Loan Loss Provision (CLLP) (H2a–H2d). Goodness-of-fit is assessed using F-statistics, R-

squared (R^2), and Adjusted R-squared (Adj. R^2) under two specifications: With and without control variables (Ln_CMC and ROA).

The results show that model performance improves substantially when firm-level control variables are included. Models for H1a–H1c yield higher explanatory power (R^2 up to 34.9%) compared to the aggregate ESG model (H1d). Similarly, the mediated models (H2a–H2c) demonstrate moderate fit, particularly when controls are incorporated. The consistently significant F-statistics ($p < 0.01$) across all specifications confirm that the explanatory variables jointly explain a meaningful share of variation in firm value.

It should be noted, however, that these statistics reflect overall model fit rather than instrument strength. As discussed in Section 4.2, the first-stage regressions revealed weak instruments, which limits the causal interpretation of the mediation results. Accordingly, the fit statistics presented here should be interpreted as descriptive indicators of explanatory performance, not as definitive evidence of mediation validity.

Table 14. Goodness-of-Fit Results for ESG → Tobin's Q Models (H1 and H2).

Hypothesis	Model Specification	F-statistic	R^2	Adjusted R^2
H1a–H1c	With controls	56.58 ***	0.3491	0.3479
	Without controls	34.78 ***	0.1661	0.1652
H1d	With controls	63.30 ***	0.1996	0.1988
	Without controls	35.86 ***	0.0270	0.0267
H2a	With controls	86.76 ***	0.3030	0.3023
	Without controls	86.96 ***	0.1330	0.1325
H2b	With controls	78.17 ***	0.3314	0.3307
	Without controls	86.52 ***	0.1518	0.1515
H2c	With controls	80.44 ***	0.2659	0.2651
	Without controls	83.32 ***	0.0894	0.0890
H2d	With controls	63.30 ***	0.1996	0.1988
	Without controls	35.86 ***	0.0270	0.0267

Note: All models are estimated using fixed-effects panel regressions with robust standard errors clustered at the firm level. F-statistics are significant at the 1% level (***), confirming joint explanatory power. Control variables (Ln_CMC and ROA) consistently improve explanatory fit. These results should be interpreted alongside the first-stage diagnostics in Section 4.2. H2d yields identical fit to H1d because ESG Total enters as a single dimension in both direct and mediated specifications.

Source: Authors' computation using STATA v.17.0 (2024).

4.5. Nonlinear regression results: Evidence of an inverted-u relationship

In this section, we explore the potential nonlinear relationship between ESG disclosure and firm value by incorporating quadratic terms into the regression models. Table 15 presents results from two model panels: Panel A, which uses standard ESG disclosure scores, and Panel B, which uses CLLP-weighted ESG disclosure variables. All estimations apply fixed effects with firm-clustered robust standard errors.

Panel A reveals mixed evidence of nonlinear dynamics across the ESG dimensions. Both the GDS and the aggregate ESG score display statistically significant linear and squared terms with opposite signs, indicating an inverted-U shaped relationship. This suggests that moderate levels of governance or total ESG disclosure are positively associated with firm value (Tobin's Q), but that excessive disclosure may lead to diminishing or negative returns. This supports the notion of diminishing

marginal legitimacy (Suchman, 1995) and aligns with prior studies warning that overly intensive ESG reporting may increase monitoring costs, create stakeholder fatigue, or signal symbolic compliance (Dhaliwal et al., 2011; Liang & Renneboog, 2017).

In contrast, EDS shows a significantly negative linear term but an insignificant squared term, indicating a predominantly negative linear relationship. SDS does not exhibit significant curvature, suggesting no substantial nonlinear effect in the social dimension.

Panel B incorporates CLLP-adjusted ESG disclosure variables, CLEDS, CLSDS, CLGDS, and CLESG, constructed from the fitted values of the 2SLS estimation. This approach reflects prudential ESG signaling, wherein disclosure is internalized into credit risk governance. The results reveal that the nonlinear pattern becomes stronger and more statistically significant for CLGDS and CLESG, where both linear and squared terms confirm an inverted-U shape. These findings suggest that when governance disclosure and total ESG efforts are integrated with Credit-based Loan Loss Provision, they can enhance firm value, but only up to a threshold, beyond which market confidence may decline. This supports the idea that stakeholders, especially creditors and investors, reward ESG transparency when it is coupled with credible governance mechanisms.

Moreover, CLEDS and CLSDS do not exhibit significant nonlinear effects, indicating that the environmental and social dimensions may be less sensitive to credit-based adjustments in the Asia-Pacific banking context. Taken together, the results provide compelling evidence that the relationship between ESG disclosure and firm value is nonlinear, particularly for the governance pillar and the aggregate ESG score. More importantly, when ESG disclosure is aligned with prudential credit risk governance, its impact on firm value becomes more robust, but only within a reasonable range. This reinforces the importance of developing ESG strategies that are transparent and embedded within institutional risk management frameworks across diverse Asia-Pacific economies.

Table 15. Quadratic regression results: nonlinear effects of ESG disclosure and CLLP-weighted ESG on firm value (Tobin's Q).

Model	Variable	Coefficient	t-Statistic	p-value	Significance
Panel A: Standard ESG Disclosure					
Model 1: EDS	EDS	−0.00150	−5.15	0.000	***
	EDS²	0.0000108	1.62	0.107	
Model 2: SDS	SDS	−0.00096	−3.48	0.001	***
	SDS²	−0.00000556	−0.86	0.392	
Model 3: GDS	GDS	0.00193	1.92	0.056	*
	GDS²	−0.0000214	−2.84	0.005	**
Model 4: ESG	ESG	0.00048	5.94	0.000	***
	ESG²	−0.00000384	−7.78	0.000	***
Panel B: CLLP-Weighted ESG Disclosure					
Model 1: CLEDS	CLEDS	−0.0310305	−1.52	0.131	
	CLEDS²	0.0000399	1.62	0.107	
Model 2: CLSDS	CLSDS	0.0004012	1.97	0.050	**
	CLSDS²	−0.00000021	−0.86	0.392	
Model 3: CLGDS	CLGDS	0.0031173	3.19	0.002	***
	CLGDS²	−0.00000322	−2.84	0.005	***
Model 4: CLESG	CLESG	0.0104	7.61	0.000	***
	CLESG²	−0.0000138	−7.78	0.000	***

Note: Panel A reports estimates using standard ESG disclosure indicators (EDS, SDS, GDS, ESG Total). Panel B presents CLLP-weighted ESG indicators, derived from fitted values in the 2SLS estimation. All regressions use fixed effects with robust standard errors clustered at the firm level. The squared terms capture potential nonlinear effects. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: Authors' computation using STATA v.17.0 (2024).

Following the instrument diagnostics in Section 4.2, additional specification checks are performed to validate the nonlinear models. The Ramsey RESET test is applied to all quadratic specifications, covering standard ESG measures and their CLLP-weighted counterparts. The results, summarized in Table 16, consistently reject the null hypothesis of no omitted variables, thereby confirming that the inclusion of quadratic terms is statistically justified.

Table 16. Ramsey RESET tests for model specification.

Model	Variable	RESET F-statistic	p-value	Interpretation
Panel A: Standard ESG Disclosure				
Model 1: EDS	EDS	23.57	0.0000	Reject H_0 → quadratic form justified
Model 2: SDS	SDS	22.94	0.0000	Reject H_0 → quadratic form justified
Model 3: GDS	GDS	32.13	0.0000	Reject H_0 → quadratic form justified
Model 4: ESG Total	ESG Total	30.60	0.0000	Reject H_0 → quadratic form justified
Panel B: CLLP-Weighted ESG Disclosure				
Model 1: CLEDS	CLEDS	23.57	0.0000	Reject H_0 → quadratic form justified
Model 2: CLSDS	CLSDS	22.94	0.0000	Reject H_0 → quadratic form justified
Model 3: CLGDS	CLGDS	32.13	0.0000	Reject H_0 → quadratic form justified
Model 4: CLESG	CLESG	30.60	0.0000	Reject H_0 → quadratic form justified

Note: This table reports the Ramsey RESET tests applied to the quadratic regression models presented in Table 15. The null hypothesis (H_0) assumes no omitted variables and correct model specification. Significant F-statistics ($p < 0.01$) across all models lead to rejection of H_0, suggesting misspecification if only linear terms are included. These results justify the inclusion of quadratic terms (ESG^2) to capture nonlinearities in the ESG–firm value relationship.
Source: Authors' computation using STATA v.17.0 (2024).

4.6. Visualizing the nonlinear relationship

To complement the regression findings, Figure 2 visually depicts the quadratic relationship between the Total ESG Disclosure Score and firm value (Tobin's Q) for banks across the Asia-Pacific region.

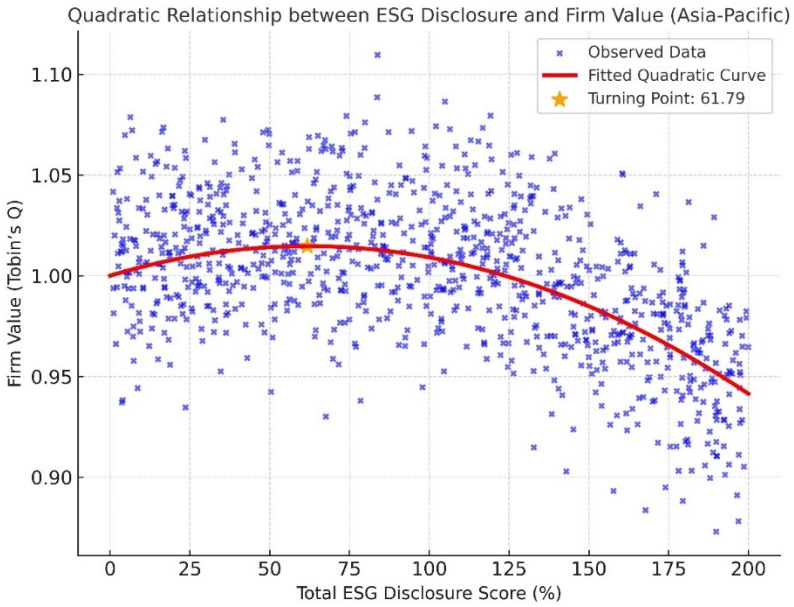

Figure 2. Quadratic relationship between ESG disclosure and firm value (Tobin's Q). The blue scatter points represent firm-level observations, while the red curve shows the fitted quadratic relationship based on fixed-effects regression. The gold star marks the estimated turning point (61.79%).

As shown in the figure, firm value initially rises with increasing ESG disclosure, reaching a peak at an ESG Disclosure Score of approximately 61.79. Beyond this threshold, however, the curve slopes downward, indicating a decline in firm value with further increases in disclosure. This validates the inverted-U relationship identified in the regression results and lends strong support to Hypothesis H3.

Importantly, this turning point should not be viewed as a universal benchmark but as an indicative threshold derived from the aggregate Asia-Pacific sample. Its precise level may plausibly vary across institutional contexts. For example, banks in emerging markets may be more vulnerable to market skepticism once disclosure exceeds moderate levels, while more mature institutions with stronger governance capacity may sustain higher levels of transparency without credibility loss. Although a comparative test of these differences is beyond the scope of this study, future research could extend this analysis by splitting subsamples between emerging and developed economies.

This pattern aligns with the signaling theory and the resource-based view (RBV). While moderate ESG disclosure may serve as a credible signal of sustainability commitment and governance quality, excessive disclosure, particularly in the absence of integration with internal risk management, may trigger market skepticism. Such over-disclosure can be perceived as symbolic or opportunistic (greenwashing) and may impose operational or compliance costs not justified by performance gains (Ersoy et al., 2022; Fatemi et al., 2018; Helfaya et al., 2023). Thus, these findings reinforce the notion that ESG transparency must be balanced with strategic credibility and institutional maturity, especially in financial institutions operating under diverse regulatory and market environments in the Asia-Pacific.

5. Discussion

5.1. ESG disclosure and firm value ambiguity

These findings, which show a negative relationship between ESG disclosure and firm value in the linear panel regressions, are in line with prior studies documenting the "ESG paradox"; that greater transparency in sustainability practices does not automatically translate into higher market valuation (Cheng et al., 2024; Tamasiga et al., 2024). Furthermore, they contrast with studies suggesting a positive valuation premium from ESG integration, indicating that the market response to disclosure remains highly context-dependent.

From the perspective of legitimacy theory (Suchman, 1995), this paradox may arise when firms adopt ESG disclosure primarily to conform to external expectations without embedding it into internal governance and risk frameworks. In such cases, disclosure becomes symbolic rather than strategic, leading to skepticism and even penalization by informed investors (Delmas & Burbano, 2011; Xu et al., 2023). These results are also consistent with broader concerns about greenwashing, where disclosure volume is emphasized more than substantive ESG integration (de Silva Lokuwaduge & De Silva, 2022).

In emerging Asia-Pacific economies, regulatory uncertainty and capacity gaps further limit banks' ability to credibly embed ESG into governance (UNDP, 2024). Hence, investors appear to evaluate not the quantity but the credibility of disclosure, rewarding signals that are risk-based and operationally embedded.

Overall, the evidence underscores the importance of distinguishing symbolic ESG disclosure and strategic ESG integration. For ESG initiatives to positively influence firm value, particularly in banking, they must be supported by credible risk governance structures and demonstrable links to core business operations rather than being confined to formal reporting.

5.2. The role of CLLP: Risk-Based ESG as a credible signal

The mediation results, showing that CLLP significantly transmits the effect of ESG disclosure to firm value, provide strong support for the signaling theory (Spence, 1973) and nuance prior findings that emphasize disclosure volume alone. When ESG practices are reinforced by prudent credit risk governance, they function as credible signals to investors and other market participants. Active and forward-looking management of loan loss provisions demonstrates superior internal capability in anticipating and mitigating credit risk, thereby transforming ESG from a compliance-oriented mechanism into a source of competitive advantage.

Specifically, the results indicate that three ESG dimensions, EDS, SDS, and GDS, positively influence firm value through the CLLP channel, confirming Hypotheses H2a–H2c. In contrast, the aggregate ESG score (Hypothesis H2d) exerts a significant negative indirect effect on Tobin's Q via CLLP.

This contrasting outcome may be explained by two mechanisms. First, aggregating ESG dimensions into a single composite index can introduce signal distortion, particularly when weightings are not uniform or contextually aligned (Berg et al., 2022). Such aggregation may obscure the differentiated value of each ESG pillar, which is especially critical in risk-sensitive industries such as banking. Second, the nonlinear regression analysis highlights an inverted-U-shaped relationship between ESG disclosure, CLLP, and firm value, with a regional turning point at 61.79%. Beyond this threshold, additional disclosure may diminish credibility or be perceived as inefficient, particularly in markets where risk governance mechanisms remain underdeveloped.

From a structural perspective, the credibility of CLLP as a mediating signal depends on balancing credit expansion with risk resilience. Loan loss provisioning that is either overly conservative or insufficiently responsive may weaken the market's interpretation of ESG commitment. Consequently, ESG evaluations should not adopt a one-size-fits-all approach but instead account for dimension-specific signals that reflect each bank's position on the ESG governance maturity curve.

In summary, ESG initiatives that are embedded within prudential mechanisms such as CLLP are more likely to be interpreted as genuine and strategically grounded. This reinforces the importance for banks, particularly in emerging and transitional economies, to align ESG disclosure with credible, risk-based governance frameworks to enhance valuation outcomes.

5.3. Nonlinear evidence: Ooptimal ESG and over-disclosure risks

The quadratic regression results confirm an inverted-U-shaped relationship between ESG disclosure and firm value, providing empirical support for Hypothesis H3. These findings demonstrate that while moderate levels of ESG disclosure are positively associated with market valuation, excessive disclosure beyond an optimal threshold reduces its effectiveness. This evidence is consistent with theoretical expectations that more disclosure is not inherently better and offers empirical nuance to prior studies that assume linear effects.

In the context of banking, an industry subject to stringent regulatory oversight and heightened sensitivity to signaling, over-disclosure may be interpreted as cosmetic or symbolic if not supported by internal governance improvements. This interpretation aligns with the legitimacy theory, which suggests that symbolic disclosure without substantive integration may undermine credibility (Suchman, 1995), and with prior findings that overly detailed reporting can impose additional compliance costs while reducing valuation benefits (Fatemi et al., 2018; Liang & Renneboog, 2017). From a resource-

based perspective, sustaining extensive ESG programs without adequate operational alignment may erode efficiency and weaken firms' competitive advantage (Cheng et al., 2014; Dhaliwal et al., 2011). Thus, the inverted-U evidence reflects not merely "investor fatigue", but the diminishing marginal credibility of disclosure once the threshold is surpassed.

The implications of this nonlinear pattern highlight the importance of adopting threshold-based ESG governance. Disclosure strategies should be aligned with firm-specific capabilities, sectoral expectations, and institutional contexts rather than seeking to maximize transparency indiscriminately. Importantly, the identified regional turning point of 61.79% should be regarded as a benchmark for Asia-Pacific banking, subject to variation across countries and levels of institutional maturity. While we do not directly test such cross-country differences, the findings underscore the need for future research to examine how institutional environments shape the optimal balance between ESG disclosure and market valuation.

5.4. Regional context: Institutional diversity across Asia-Pacific

The empirical findings, based on a regional dataset, reflect the institutional diversity of Asia-Pacific banking systems, where ESG disclosure practices are shaped by uneven regulatory and governance capacities. While advanced economies such as Japan, Australia, and Singapore benefit from mature ESG frameworks supported by established disclosure standards and financial market infrastructures, many emerging markets continue to face institutional voids, including limited regulatory capacity, inconsistent reporting norms, and gaps in ESG literacy (CFA Institute, 2019; OECD, 2023).

These results are consistent with prior literature emphasizing that institutional heterogeneity affects the credibility and the valuation of ESG disclosures (Ioannou & Serafeim, 2015). Banks in the region are often required to respond simultaneously to global ESG expectations, driven by investor pressure, transnational guidelines, and rating agencies, while operating within local environments characterized by weak enforcement or political and market constraints. Such cross-border tensions help explain why ESG disclosures may remain fragmented or fail to translate into higher firm value, particularly in emerging markets where institutional infrastructure is not fully capable of supporting substantive ESG integration.

The policy implications point to the need for context-sensitive governance mechanisms. Rather than adopting a one-size-fits-all approach, regulators should calibrate ESG disclosure requirements to the maturity of local financial systems. Embedding ESG into supervisory credit risk frameworks, including mechanisms such as CLLP, may help align disclosure with prudential oversight and mitigate the risk of symbolic compliance. By doing so, ESG efforts can be harmonized across institutionally diverse jurisdictions, enhancing credibility in the eyes of investors and the resilience of the regional financial system.

5.5. Theoretical synthesis and scientific contributions

The empirical results, demonstrating a negative direct effect of aggregate ESG disclosure, the mediating role of CLLP, and an inverted-U nonlinear pattern, highlight the complexity of how sustainability practices affect firm value. These findings provide an opportunity to integrate multiple theoretical perspectives into a coherent framework.

From the perspective of the stakeholder theory (Freeman, 1984), ESG initiatives are expected to enhance legitimacy and stakeholder trust; Yet. the evidence of limited or even negative valuation effects underscores the importance of legitimacy theory (Suchman, 1995), which cautions that symbolic rather than substantive disclosure may erode market confidence. The strong mediating role of CLLP offers support for signaling theory (Spence, 1973), showing that risk-based governance mechanisms transform ESG practices into credible signals of managerial quality. Finally, the inverted-U relationship resonates with the resource-based view (Barney, 1991), indicating that ESG disclosure generates value only when aligned with organizational capabilities and does not overstretch firm resources.

Against this theoretical backdrop, we make three contributions. First, we introduce CLLP as a novel conceptual bridge that links ESG disclosure quality to prudential banking practices. Second, we provide empirical evidence of a nonlinear ESG–value relationship within transnational financial systems, emphasizing the importance of thresholds and contextual variation. Third, we advance the literature by demonstrating that the valuation impact of ESG depends not only on disclosure volume but also on its integration into risk governance, with direct implications for sustainable finance and the pursuit of the SDGs.

6. Conclusions and implications

The empirical evidence from this study reveals a complex relationship between ESG disclosure and bank firm value in the Asia-Pacific region. Linear models show that ESG disclosure does not consistently improve valuation and may even exert a negative effect when not supported by strong internal risk governance. In contrast, when ESG initiatives are coupled with prudent credit provisioning, proxied by CLLP, they generate credible signals that the market values positively. Furthermore, the nonlinear analysis identifies an inverted-U-shaped pattern, with an optimal threshold of disclosure beyond which the benefits decline, highlighting the risks of over-disclosure.

These findings advance theory in several ways. They integrate stakeholder, legitimacy, signaling, and resource-based perspectives into a unified risk-based ESG framework. Specifically, the results demonstrate that ESG effectiveness depends not only on transparency but also on the extent to which disclosures are embedded in governance and risk management structures. CLLP emerges as a novel conceptual bridge, illustrating how risk-based practices can transform ESG disclosure from symbolic compliance into credible strategic signaling. The inverted-U evidence further aligns with the resource-based view, suggesting that excessive ESG activities may stretch organizational capacities and reduce efficiency.

The study also offers clear practical and policy implications.

- For regulators: Policies should prioritize the quality and credibility of ESG reporting, complementing disclosure mandates with supervisory standards for ESG-based risk management.
- For bank management: ESG initiatives must be embedded within credit risk governance systems, with CLLP serving as an internal readiness indicator of genuine commitment.
- For investors: ESG evaluations should account for embedded risk signals, rewarding firms that integrate sustainability into prudential practices rather than those that report extensively but superficially.
- For sustainable finance agendas: Aligning ESG disclosure with prudential oversight can discourage symbolic compliance, strengthen financial resilience, and advance progress toward the SDGs in diverse institutional settings.

Finally, we acknowledge several limitations. The reliance on Bloomberg ESG data may obscure sector-specific materiality and forward-looking sustainability dimensions. First-stage diagnostics also suggest weak instruments, warranting caution in interpreting mediation effects. The nonlinear threshold identified (61.79%) represents a regional benchmark and should not be generalized across countries. Moreover, while robustness checks are conducted through lagged ESG variables and alternative winsorization levels, subsample analyses, such as comparing advanced and emerging Asia-Pacific markets, are not included. In addition, the use of Two-Stage Least Squares (2SLS) provides evidence consistent with mediation but does not constitute a formal mediation test; researchers could apply simultaneous equation frameworks such as structural equation modeling (SEM) or Three-Stage Least Squares (3SLS) to formally validate the mediation mechanism. In the future, researchers may also employ alternative ESG datasets (e.g., MSCI, Sustainalytics), dynamic modeling, subsample comparisons, or qualitative case studies to capture long-term and context-specific dynamics of ESG internalization. These limitations notwithstanding, the study provides a rigorous empirical foundation for advancing risk-based ESG research in banking.

Author contributions

Netti Natarida Marpaung: Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization, Data curation. Prof. Sugeng Wahyudi: Supervision, Validation, Writing – review & editing. Dr. Irene Rini Demi Pangestuti: Co-supervision, Writing – review & editing.

Use of AI tools declaration

The authors declare that they used Grammarly for minor proofreading purposes only. All substantive content, including the research design, data analysis, interpretation, and conclusions, was entirely developed by the authors without the assistance of any generative AI tools.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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