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Environmental, Social, and Governance (ESG) Practices and Financial Stability: Evidence from Egyptian Banks

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Abstract

This study investigates the relationship between environmental, social, and governance (ESG) practices and the financial stability of Egyptian banks. While the growing body of ESG literature generally suggests that sustainability enhances institutional resilience, empirical evidence remains mixed, particularly in emerging banking markets characterized by macroeconomic volatility and evolving regulatory frameworks. Egypt provides a relevant empirical setting owing to its recent banking reforms, increasing emphasis on sustainable finance, and significant exchange-rate fluctuations during the study period.

Using a balanced panel dataset of 12 Egyptian banks covering the period 2015–2024 (120 bank-year observations), the study estimates four separate panel-data models to examine the effects of the aggregate ESG index and its environmental (E), social (S), and governance (G) dimensions on financial stability, measured by the Z-score. Separate model specifications are employed to avoid multicollinearity between the composite ESG index and its constituent dimensions. Bank size and the exchange rate are included as control variables. Model selection is based on conventional panel-data specification tests, while statistical inference relies on bank-clustered robust standard errors following comprehensive diagnostic testing. The robustness of the findings is further evaluated using the Correlated Random Effects (CRE–Mundlak) approach.

The empirical results indicate that overall ESG performance is positively and significantly associated with bank financial stability. Among the individual sustainability dimensions, the environmental pillar exhibits the strongest positive effect, governance demonstrates a weaker but statistically significant contribution, whereas the social dimension does not exert a statistically significant contemporaneous influence. Bank size is consistently associated with lower financial stability, while exchange-rate movements display a positive and significant relationship with bank stability throughout the estimated models. Robustness analyses confirm that these findings remain stable across alternative model specifications.

The findings offer practical insights for banks, regulators, and policymakers seeking to strengthen financial stability through sustainability-oriented strategies.

Keywords: Environmental, Social, and Governance (ESG); Financial Stability; Sustainable Finance; Egyptian Banks; Exchange Rate.

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1. Introduction

Over the past decade, environmental, social, and governance (ESG) considerations have become an integral component of banking regulation, risk management, and strategic decision-making. Financial stability is no longer evaluated solely through traditional accounting and prudential indicators; it increasingly reflects banks' ability to identify, manage, and mitigate ESG-related risks that may affect their long-term resilience. Consequently, regulators, investors, and international financial institutions have progressively recognized sustainability practices as a strategic determinant of banking resilience rather than merely a corporate responsibility initiative.

This transformation is particularly relevant in emerging economies, where macroeconomic instability and institutional constraints intensify banks' exposure to financial risk. Egypt provides a particularly informative setting in this respect. During the past decade, the Egyptian banking sector has experienced substantial regulatory reforms alongside the Central Bank of Egypt's increasing commitment to sustainable finance and ESG integration. Over the same period, the economy was exposed to repeated macroeconomic disturbances, most notably major exchange-rate adjustments that significantly altered banks' operating environment and risk profiles. These developments provide a natural setting for examining whether sustainability practices are associated with stronger financial stability under conditions of heightened economic uncertainty.

Despite the rapid expansion of ESG research, empirical evidence regarding its relationship with bank financial stability remains inconclusive. Existing studies report positive, insignificant, and even adverse associations, reflecting differences in institutional environments, ESG measurement approaches, sample composition, and empirical methodologies. Moreover, most available evidence originates from developed financial systems, whereas relatively little is known about the ESG–financial stability relationship in emerging banking markets. The Egyptian banking sector remains particularly underexplored despite its growing strategic importance and distinctive macroeconomic environment. Furthermore, previous research has largely focused on aggregate ESG measures, while comparatively few studies investigate whether the environmental, social, and governance dimensions contribute differently to banking stability.

Addressing this issue is important not only from an academic perspective but also from a policy standpoint. Understanding which sustainability dimensions are more closely associated with banking resilience can assist regulators and bank managers in designing more effective sustainability strategies while supporting financial system stability in periods of macroeconomic uncertainty.

Against this background, this study examines the relationship between ESG practices and the financial stability of Egyptian banks over the period 2015–2024. To distinguish the heterogeneous contribution of sustainability dimensions, four separate panel-data models are estimated for the aggregate ESG index and each of its environmental, social, and governance components. Estimating these models separately avoids the mechanical multicollinearity that would arise from jointly including the composite ESG index and its constituent dimensions

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while allowing a direct comparison of their relative explanatory power. The analysis further controls for bank size and exchange-rate movements to isolate the association between ESG practices and financial stability from institution-specific characteristics and common macroeconomic conditions.

This study contributes to the literature in three principal ways. First, it provides new evidence from the Egyptian banking sector, an important emerging market that remains underrepresented in the sustainable banking literature. Second, it distinguishes the heterogeneous associations of the environmental, social, and governance dimensions with bank financial stability through separate empirical specifications, thereby overcoming the multicollinearity inherent in composite ESG measures. Third, it develops a bank-level ESG disclosure index based on systematic content analysis of official disclosures and evaluates the estimated relationships within a comprehensive panel-data framework supported by extensive diagnostic testing, robustness analyses, and economic significance assessment. Collectively, these contributions advance current understanding of how sustainability practices relate to banking resilience in emerging economies.

2. Literature Review and Hypothesis Development

2.1. ESG Practices and the Financial Stability of Banks: Theoretical Perspectives and Empirical Evidence

Recent banking research has witnessed a notable shift in explaining the relationship between environmental, social, and governance (ESG) practices and financial stability. Rather than focusing solely on whether such a relationship exists, contemporary research increasingly seeks to understand the mechanisms through which sustainability practices influence banks' resilience, risk management capacity, and long-term financial soundness. Within this perspective, ESG is no longer regarded merely as a regulatory compliance requirement or a reputational consideration; instead, it is increasingly viewed as a strategic organizational resource capable of strengthening institutional resilience and supporting sustainable value creation. This perspective is consistent with **Stakeholder Theory**, which argues that sustained engagement with key stakeholders enhances organizational legitimacy, mitigates risk exposure, strengthens stakeholder confidence, and ultimately contributes to superior long-term organizational performance.

A growing body of recent empirical research broadly supports this theoretical perspective. Evidence from both corporate and banking settings indicates that stronger ESG performance is generally associated with greater financial resilience, although the underlying transmission mechanisms differ across institutional environments. (Egorova, Lavrukhina, & Karminsky, 2024), for example, demonstrate that stronger ESG performance enhances firms' financial resilience during periods of economic uncertainty, emphasizing the importance of environmental initiatives, climate-risk management, and governance quality in strengthening organizational stability. Consistent with these findings, banking studies suggest that sustainability practices improve financial resilience by strengthening governance quality, enhancing risk-management systems, increasing organizational adaptability, and supporting income diversification (Pyka, Karkowska, & Nocoń, 2025); (Almulla, Albaity, & Al-Tamimi,

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2025); (Choi, Ryu, & You, 2024); (Sassi & Lassoued, 2026); (Rashed, Wu, Abdelbaky, Elamer, & Mohsen, 2026).

Comparable evidence has also emerged from the MENA region. (Aburasul, Abd Rahman, Al-Qudah, Alanazi, & Alnaim, 2025) report that stronger ESG performance reduces banks' financial constraints, with the environmental and governance dimensions exerting the strongest influence. Their findings further indicate that political instability amplifies the value of sustainability practices, suggesting that ESG becomes increasingly important under adverse macroeconomic conditions. Likewise, (Hamidjaya & Danarsari, 2026) show that sustainability practices mitigate the adverse effects of liquidity creation on financial stability, thereby improving banks' capacity to absorb macroeconomic shocks. (Mirza, Umar, Lobont, & Safi, 2025) provide additional evidence by demonstrating that ESG-oriented lending enhances banks' risk-adjusted returns while reducing non-performing loans, particularly among smaller institutions. Collectively, these studies indicate a clear evolution in banking research, where ESG is increasingly regarded as a strategic determinant of financial resilience rather than merely a regulatory obligation or corporate responsibility initiative.

Despite the generally favorable evidence, the literature has not reached a consensus regarding either the magnitude or the persistence of the relationship between ESG practices and financial stability. While the dominant view suggests that sustainability initiatives strengthen banking resilience, a growing number of studies indicate that these benefits may vary across institutional settings, performance measures, and time horizons.

For instance, (Pyka, Karkowska, & Nocoń, 2025) argue that although ESG implementation may temporarily constrain profitability because of the costs associated with sustainability investments, it simultaneously strengthens financial stability over the longer term. In contrast, (Ben Ali & Chouaibi, 2026) report a negative association between the aggregate ESG score and bank performance, while also demonstrating that the environmental, social, and governance dimensions exert substantially different effects. Similarly, (Canli & Sercemeli, 2026); (Lunawat, Elmarzouky, & Shohaieb, 2025) show that both the direction and statistical significance of the ESG–performance relationship depend on the financial indicators employed and the institutional environment under investigation.

Rather than representing contradictory theoretical conclusions, these divergent findings are more appropriately interpreted as evidence of contextual heterogeneity. Differences in regulatory quality, institutional characteristics, ESG measurement frameworks, sample composition, and empirical specifications appear to explain much of the observed variation across studies. Consequently, the existing literature increasingly suggests that the relationship between ESG practices and financial stability is conditional rather than universal, reinforcing the importance of examining this association within specific institutional and economic contexts.

Evidence from the Egyptian banking sector remains comparatively limited and fragmented. Existing research has primarily examined the economic, governance, and reporting implications of ESG adoption rather than its direct relationship with bank financial stability. Consequently, although the literature has generated valuable insights into the

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economic consequences of sustainability practices, the mechanisms through which ESG contributes to banking resilience in Egypt remain insufficiently understood.

(El Sayed, 2025), for example, reports a positive association between ESG performance and bank profitability, although this relationship weakens under conditions of elevated cybersecurity risk. Similarly, (Rezk, 2025) finds that sustainability investments contribute to superior long-term financial performance, supporting the view that ESG practices create long-run economic value. From a different perspective, (Abbas & Abdel Megid, 2025) examine the determinants of ESG disclosure among Egyptian banks and report that market value and sustainable financial growth positively influence ESG disclosure, whereas operational efficiency exhibits a negative association. Their findings suggest that variations in ESG disclosure are partly driven by bank-specific financial characteristics rather than sustainability considerations alone.

Additional evidence also points to broader economic benefits associated with ESG adoption. (Ayoub, 2025) demonstrates that stronger ESG performance reduces stock price volatility, while (Habib & Mourad, 2024) show that sustainability-oriented banks exhibit higher financial reporting quality and lower levels of earnings management. Collectively, these studies indicate that ESG practices are associated with improvements in profitability, market performance, disclosure quality, and financial reporting outcomes within the Egyptian banking sector.

Nevertheless, direct empirical evidence linking ESG practices to bank financial stability remains scarce. More importantly, existing Egyptian studies have generally focused on aggregate economic or reporting outcomes and have rarely examined whether the environmental, social, and governance dimensions contribute differently to banking stability. Accordingly, whether ESG practices enhance the financial resilience of Egyptian banks—and which sustainability dimension plays the most influential role—remains an unresolved empirical question that warrants further investigation.

2.2. Differential Effects of the Environmental, Social, and Governance Dimensions on Financial Stability

As ESG research has matured, scholarly attention has progressively shifted from evaluating the aggregate ESG construct toward examining the distinct contributions of its environmental, social, and governance dimensions. This transition reflects the growing recognition that combining the three pillars into a single composite measure may conceal their heterogeneous effects on financial stability. Because each dimension captures different sources of risk management, value creation, and stakeholder engagement, their influence on banking resilience is unlikely to be uniform. Building upon the theoretical perspectives discussed above, this view is consistent with **Stakeholder Theory**, which emphasizes that sustainable value creation depends on balancing the interests of multiple stakeholders, while **Agency Theory** suggests that effective governance mechanisms reduce agency conflicts and improve managerial decision-making. Together, these perspectives imply that the three ESG dimensions are expected to influence financial stability through different channels and with varying degrees of effectiveness.

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Among the three ESG pillars, the **environmental dimension** exhibits the greatest degree of empirical consistency. A growing body of evidence indicates that superior environmental performance strengthens banks' resilience by improving risk management, mitigating climate-related financial exposures, and enhancing resource efficiency (Choi, Ryu, & You, 2024); (Sassi & Lassoued, 2026); (Işık, Zolfani, Shabir, & Šaparauskas, 2025); (Magazzino, Arnone, Leogrande, & Gattone, 2026). (Palmieri, Polato, & Floreani, 2025) further demonstrate that banks combining strong environmental performance with green bond issuance experience lower non-performing loan ratios and improved asset quality, thereby reinforcing financial stability through indirect risk-reduction mechanisms. Collectively, these studies suggest that environmental performance has evolved beyond a corporate sustainability objective to become an integral component of banks' risk-management architecture, particularly in addressing climate-related financial risks.

Evidence concerning the **social dimension**, however, is considerably more heterogeneous. (Pyka, Karkowska, & Nocoń, 2025) identify the social pillar as the strongest contributor to improvements in the Z-score, emphasizing its role in strengthening stakeholder trust and enhancing institutional reputation. By contrast, (Canli & Sercemeli, 2026) report a positive association with profitability but find no significant effect on financial stability, whereas (Mahboub & Ghanem, 2025), together with (Chua & Byun, 2025), document adverse effects on financial performance that they attribute to the costs associated with social responsibility initiatives. These findings indicate that the effectiveness of social investments depends not only on the characteristics of the social dimension itself but also on institutional maturity, regulatory quality, and the broader economic environment. Consequently, the contribution of the social pillar appears to be particularly sensitive to contextual differences across countries and financial systems.

Compared with the other two pillars, the **governance dimension** demonstrates the strongest theoretical foundation and the highest degree of empirical consistency. Existing evidence consistently shows that board independence, effective internal control systems, high-quality disclosure, and sound governance structures strengthen risk oversight and enhance financial resilience (Mahboub & Ghanem, 2025); (Palmieri, Polato, & Floreani, 2025); (Sassi & Lassoued, 2026). Evidence from the Egyptian context is broadly consistent with these findings. (Fouad, 2025), in a study of Egyptian financial institutions, reports that board independence, transparency, and effective risk management are positively associated with financial sustainability, whereas CEO duality exerts a negative effect on organizational performance. Collectively, these findings reinforce the central proposition of **Agency Theory**, namely that effective governance mechanisms mitigate agency conflicts, improve managerial decision-making, and strengthen institutional resilience. Although the magnitude of governance effects varies across institutional settings, the direction of the relationship remains remarkably consistent across empirical studies.

Empirical evidence from **Egypt** remains comparatively limited. The few available studies examining the individual ESG dimensions provide only partial evidence and focus predominantly on non-financial firms. (Mahboub & Ghanem, 2025), for instance, report

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heterogeneous effects across the three ESG pillars, finding no significant contribution from the environmental dimension, a negative association for the social dimension, and a positive effect of governance on corporate financial performance. Although these findings further support the international evidence that the three ESG dimensions operate through distinct mechanisms, they cannot be directly generalized to the banking sector because they neither examine banks nor employ banking-specific measures of financial stability, such as the Z-score.

Taken together, the literature suggests that the principal source of inconsistency lies not in the relevance of ESG itself but in the heterogeneous influence of its environmental, social, and governance dimensions. Consequently, relying exclusively on an aggregate ESG indicator may obscure the distinct contribution of each sustainability pillar and partly explain the mixed empirical findings reported in previous studies. Identifying the relative contribution of each ESG dimension therefore remains an important unresolved issue in the banking literature. Addressing this question provides the conceptual foundation for the research hypotheses and empirical models developed in the following section.

2.3. Control Variables: Bank Size and Exchange Rate

The relationship between ESG practices and financial stability cannot be adequately explained by sustainability performance alone. Financial stability is simultaneously influenced by bank-specific characteristics and macroeconomic conditions that shape banks' risk profiles and operating environments. Consequently, empirical studies routinely incorporate control variables to isolate the independent association between ESG practices and financial stability, reduce omitted-variable bias, and improve model specification. Among the various control variables employed in the banking literature, **bank size** represents the most widely used institution-specific characteristic, whereas the **exchange rate** captures economy-wide macroeconomic shocks that simultaneously affect all banks.

- **Bank Size**

Bank size is one of the most frequently employed control variables in studies examining the relationship between ESG practices and bank performance or financial stability and is commonly measured by the natural logarithm of total assets. Larger banks generally benefit from economies of scale, broader funding opportunities, more diversified income sources, and greater capacity to invest in technology, regulatory compliance, and advanced risk-management systems. These advantages may facilitate the implementation of sustainability initiatives while enhancing banks' resilience to financial shocks (Hamidjaya & Danarsari, 2026); (Sassi & Lassoued, 2026); (Pyka, Karkowska, & Nocoń, 2025); (Choi, Ryu, & You, 2024).

However, the literature does not support a universally positive relationship between bank size and financial stability. Although larger institutions benefit from scale advantages, they are also characterized by greater organizational complexity, more diversified business models, and higher exposure to systemic risk, all of which may offset the benefits associated with size. Consequently, the effect of bank size depends largely on banks' operational efficiency, capitalization, governance quality, and the institutional environment in which they operate, explaining the mixed empirical evidence reported across previous studies.

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Evidence from Egypt and other regional markets is broadly consistent with this perspective. (El Sayed, 2025) includes bank size when examining the profitability implications of ESG adoption in Egyptian banks, while (Rezk, 2025); (Ayoub, 2025); (Mahboub & Ghanem, 2025) similarly incorporate firm size—measured by the natural logarithm of total assets—as a standard control variable in their empirical models. Collectively, these studies indicate that bank size is primarily included to control for structural heterogeneity across institutions rather than to evaluate its direct economic effect. Consistent with this literature, the present study measures bank size as the natural logarithm of total assets and includes it as a control variable in all empirical models.

- **Exchange Rate and Macroeconomic Shocks**

Beyond bank-specific characteristics, the banking literature increasingly emphasizes the importance of controlling for macroeconomic conditions when analysing financial stability. Banks operate within broader economic environments shaped by monetary policy, inflation, economic activity, interest rates, and exchange rate movements. Because these factors generate common shocks that simultaneously affect all financial institutions, failing to account for them may bias the estimated relationship between ESG practices and financial stability.

Among macroeconomic variables, the exchange rate is particularly important in emerging economies, where currency markets are generally characterized by greater volatility and stronger exposure to external financial shocks. Exchange rate fluctuations affect banks through several transmission channels, including the revaluation of foreign-currency assets and liabilities, changes in external financing costs, higher debt-servicing burdens for foreign-currency borrowers, and subsequent effects on asset quality, profitability, liquidity, and capital adequacy. Through these mechanisms, exchange rate movements ultimately influence banks' financial stability.

Empirical evidence consistently supports this relationship. (Kasman, Vardar, & Tunç, 2011) document a significant negative effect of exchange rate volatility on Turkish bank stock returns, highlighting banks' sensitivity to foreign exchange risk. More recent evidence similarly indicates that greater exchange rate volatility is associated with lower **Z-scores**, implying higher levels of banking risk. Extending this evidence, (Montes & do Nascimento Valladares, 2026), using panel data for 92 countries over the period 2000–2019, demonstrates that exchange rate stability and monetary policy independence contribute to lower banking risk, whereas greater financial openness combined with inconsistent macroeconomic policies increases banking sector vulnerability. Likewise, comparative banking studies identify exchange rate stability as one of the principal macroeconomic determinants of banking efficiency alongside economic growth, inflation, and monetary conditions. Collectively, these findings highlight the importance of controlling for exchange rate conditions when examining banking stability.

The relevance of the exchange rate is particularly pronounced in emerging economies, where financial systems are generally more vulnerable to external disturbances and banks differ substantially in their ability to manage foreign exchange risk. Although recent evidence, including (Hamidjaya & Danarsari, 2026), indicates that ESG practices strengthen banks' risk-management capabilities, empirical studies simultaneously examining ESG practices and exchange rate dynamics within a unified banking framework remain relatively scarce. This gap further justifies incorporating exchange rate movements as a macroeconomic control variable when evaluating the relationship between ESG practices and the financial stability of banks.

2.4. Justification for the Control Variables

Drawing on the preceding literature, this study incorporates both **bank size** and the **exchange rate** as control variables to isolate the independent effect of ESG practices on the financial stability of Egyptian banks. Bank size captures structural heterogeneity across financial institutions, whereas the exchange rate reflects economy-wide macroeconomic shocks that simultaneously influence banks' operating environments. Including both variables therefore enables the empirical models to distinguish the effects of sustainability practices from those arising from institutional characteristics or changes in macroeconomic conditions.

The inclusion of the exchange rate is particularly important in the Egyptian context. During the study period (2015–2024), the Egyptian economy experienced substantial exchange rate adjustments that significantly affected inflation, financing costs, foreign-currency exposures, credit quality, bank profitability, and capital positions. To account for these economy-wide influences, this study employs the annual average EGP/USD exchange rate as a common time-varying macroeconomic control applicable to all banks in the sample, while bank size—measured as the natural logarithm of total assets—captures differences in institutional scale and operational capacity.

Collectively, these control variables improve model specification by reducing omitted-variable bias and enhancing the reliability of the estimated relationship between ESG practices and financial stability. Their inclusion ensures that the estimated ESG coefficients reflect the independent contribution of sustainability practices after accounting for both institution-specific characteristics and macroeconomic conditions, thereby strengthening the robustness and interpretability of the empirical findings.

2.5. Research Gap and Contribution of the Present Study

The preceding review indicates that, despite the rapid expansion of research on ESG and banking stability, several important issues remain unresolved. Existing evidence generally supports the view that sustainability practices can enhance financial resilience through improved risk management, stronger stakeholder relationships, and more effective governance. However, empirical findings remain far from uniform, reflecting differences in institutional environments, sustainability metrics, financial stability measures, and empirical modelling strategies.

These inconsistencies are particularly evident in emerging economies. Within the Egyptian context, prior research has largely examined the economic and governance implications of ESG adoption, including profitability, market valuation, financial reporting quality, and disclosure practices. By comparison, considerably less attention has been devoted to the direct relationship between sustainability practices and banking financial stability,

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despite the increasing importance of banking resilience for regulators and policymakers, especially during periods of substantial monetary and macroeconomic adjustment.

An additional limitation concerns model specification. A large proportion of previous studies relies exclusively on aggregate ESG indicators, implicitly assuming that the environmental, social, and governance dimensions affect financial stability through similar channels. Such an approach may obscure the heterogeneous contribution of each sustainability pillar. Furthermore, jointly incorporating the composite ESG index and its underlying dimensions within a single regression framework introduces substantial multicollinearity because the aggregate indicator is mechanically derived from its constituent components. This issue has received only limited methodological attention in the existing literature.

The literature also provides limited evidence on the interaction between sustainability practices and macroeconomic conditions. Several studies examining ESG and banking stability do not explicitly distinguish bank-specific effects from economy-wide shocks. Consequently, changes in financial stability may partly reflect macroeconomic disturbances rather than sustainability practices themselves. This issue is particularly relevant during periods of pronounced exchange rate volatility, where common monetary shocks simultaneously affect the entire banking system.

A further methodological limitation relates to ESG measurement. Most empirical studies rely on commercial ESG ratings obtained from international databases, which often provide incomplete coverage of Egyptian banks and may not fully capture the disclosure characteristics of the domestic banking sector. Comparatively few studies construct institution-specific ESG measures based on systematic content analysis of annual reports, sustainability reports, and official corporate disclosures.

Methodological differences also extend to the measurement of financial stability. Although the Z-score has become one of the most widely accepted banking stability indicators because it jointly captures profitability, capitalization, and earnings volatility, its application in examining the relationship between ESG practices and the financial stability of Egyptian banks remains limited. Likewise, several studies pay insufficient attention to the econometric properties of panel data, including cross-sectional dependence, heteroskedasticity, serial correlation, and the robustness of estimation under alternative model specifications. Addressing these issues is particularly important when banks are exposed to common macroeconomic shocks—such as exchange rate movements—that generate correlated disturbances across cross-sectional units.

Motivated by these limitations, the present study makes four principal contributions.

First, it provides new empirical evidence from the Egyptian banking sector using a balanced panel comprising 12 commercial banks over the period 2015–2024, yielding 120 bank-year observations. This period encompasses substantial regulatory, monetary, and macroeconomic developments, offering an appropriate setting for examining the relationship between ESG practices and financial stability in an emerging market characterized by significant exchange rate adjustments.

Second, the study estimates four separate econometric models. The first evaluates the effect of the aggregate ESG index, while the remaining three estimate the independent effects of the environmental (E), social (S), and governance (G) dimensions. This modelling strategy identifies the relative contribution of each sustainability pillar while avoiding the multicollinearity associated with simultaneously including the composite index and its components.

Third, rather than relying on externally supplied ESG ratings, the study develops a bank-level ESG disclosure index through systematic content analysis of annual reports, sustainability reports, and official disclosures. The index comprises 30 disclosure items distributed across eight environmental, ten social, and twelve governance indicators, providing a measurement framework tailored to the disclosure practices of Egyptian banks while ensuring consistent measurement across institutions and over time.

Fourth, financial stability is measured using the Z-score, while bank size and the annual EGP/USD exchange rate are incorporated as control variables representing, respectively, bank-specific structural characteristics and common macroeconomic conditions. The exchange rate is introduced as a control variable rather than as a primary explanatory or moderating variable, allowing the analysis to isolate the independent contribution of ESG practices from economy-wide monetary shocks.

Methodologically, the study adopts a comprehensive empirical framework that combines preliminary data diagnostics, panel-data specification tests, cross-sectional dependence and unit-root analyses, model selection between pooled, fixed-effects, and random-effects estimators, diagnostic testing, and bank-clustered robust standard errors. The robustness of the findings is further evaluated using the correlated random effects (CRE–Mundlak) approach together with an assessment of the economic significance of the estimated coefficients.

Overall, the study extends the literature by integrating contextual, methodological, and empirical considerations within a unified analytical framework. Rather than merely re-examining the relationship between ESG practices and financial stability, it distinguishes between the effects of the aggregate ESG construct and its individual dimensions while simultaneously accounting for bank-level heterogeneity and economy-wide shocks. These contributions provide the analytical foundation for the research hypotheses and empirical models developed in the following section.

3. Methodology

This section describes the empirical design used to examine the relationship between sustainability practices and the financial stability of Egyptian banks. It presents the estimation strategy, research hypotheses, variable measurement, model specifications, and the sequence of econometric procedures employed to obtain reliable statistical inference.

3.1. Empirical Strategy and Model Specification

The study examines the relationship between ESG practices and the financial stability of Egyptian banks within a panel-data framework. The empirical design accounts for several features that commonly arise in banking panels, including unobserved bank heterogeneity, cross-sectional dependence, serial correlation, heteroskedasticity, and potential

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multicollinearity between the aggregate ESG index and its constituent dimensions. A multi-stage estimation strategy is therefore adopted to identify an appropriate model specification and ensure robust inference.

The analysis begins with a comprehensive assessment of data quality. The dataset is examined for completeness, missing observations, duplicate records, and potentially influential outliers. Descriptive statistics are then reported to summarize the distribution and variability of the study variables. Distributional properties are evaluated using normality tests, while pairwise correlations and variance inflation factors are employed to assess preliminary associations and detect potentially harmful multicollinearity among variables included jointly in each specification.

The panel properties of the data are subsequently examined. Cross-sectional dependence is tested to determine whether banks are jointly affected by common economic and financial shocks. Panel unit-root tests are then applied to assess the stationarity of the variables. Where cross-sectional dependence is detected, second-generation unit-root procedures serve as the primary basis for inference, while first-generation tests are reported for comparison and sensitivity assessment.

Pooled ordinary least squares is initially estimated as a benchmark. The Breusch–Pagan Lagrange Multiplier test is then used to determine whether panel estimators are preferable to the pooled specification. Where panel effects are present, the Hausman test is employed to discriminate between fixed-effects and random-effects estimators. This decision is further evaluated using the correlated random effects formulation proposed by Mundlak.

The selected models are subjected to diagnostic testing for heteroskedasticity, serial correlation, and residual cross-sectional dependence. In light of the identified disturbances, statistical inference is based on entity-clustered robust standard errors, which allow observations to be correlated within each bank over time.

Finally, the stability of the findings is assessed using the correlated random effects–Mundlak specification as an alternative estimator. Statistical significance is complemented by an economic significance analysis to evaluate whether the estimated coefficients are economically meaningful rather than merely statistically distinguishable from zero.

3.2. Research Hypotheses

Building on the theoretical arguments and empirical evidence reviewed in the preceding section, the study tests whether the aggregate ESG index and its individual pillars are significantly associated with the financial stability of Egyptian banks. Given the mixed findings documented across institutional settings and ESG dimensions, the hypotheses are formulated in non-directional terms:

H1. The aggregate ESG index has a statistically significant effect on the financial stability of Egyptian banks.

H2. The environmental dimension has a statistically significant effect on the financial stability of Egyptian banks.

H3. The social dimension has a statistically significant effect on the financial stability of Egyptian banks.

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H4. The governance dimension has a statistically significant effect on the financial stability of Egyptian banks.

Table 1 Research Hypotheses

Hypothesis	Relationship Examined	Explanatory Variable	Dependent Variable
H1	Aggregate sustainability practices and financial stability	ESG	Z-score
H2	Environmental practices and financial stability	E	Z-score
H3	Social practices and financial stability	S	Z-score
H4	Governance practices and financial stability	G	Z-score

3.3. Variable Definition and Measurement

The dependent variable is bank financial stability, measured by the Z-score. The aggregate ESG index and its environmental, social, and governance components constitute the principal explanatory variables. Bank size and the annual EGP/USD exchange rate are included as bank-specific and macroeconomic controls, respectively.

Table 2: Variable Definitions and Measurement

Variable	Symbol	Classification	Measurement
Financial stability	Z-score	Dependent	$Z\text{-}Score_{it} = \frac{ROA_{it} + \left(\frac{Equity_{it}}{Total\ Assets_{it}}\right)}{\sigma_i(ROA)}$
Aggregate sustainability index	ESG	Explanatory	Sum of disclosed sustainability items, ranging from 0 to 30
Environmental dimension	E	Explanatory	Sum of disclosed environmental items, ranging from 0 to 8
Social dimension	S	Explanatory	Sum of disclosed social items, ranging from 0 to 10
Governance dimension	G	Explanatory	Sum of disclosed governance items, ranging from 0 to 12
Bank size	Size	Control	Natural logarithm of total assets
Exchange rate	EXR	Control	Annual average EGP/USD exchange rate

Note: The standard deviation of return on assets used in the Z-score calculation, (σί(ROA), is computed separately for each bank over the study period.

The Z-score measures the distance from insolvency by combining profitability, capitalization, and earnings volatility. Higher values indicate greater financial stability and a lower probability that losses will exhaust a bank’s equity capital.

The ESG measures are constructed using a binary disclosure-scoring procedure. Each item receives a value of one when the relevant practice or disclosure is identified in the bank’s official reports and zero otherwise. The aggregate index is the sum of the environmental, social, and governance scores.

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3.4. Rationale for the Control Variables

- **Bank Size**

Bank size is included to account for structural heterogeneity across institutions. Scale may affect financial stability through economies of scale and scope, funding and income diversification, access to capital, investment in risk-management systems, and regulatory compliance capacity. Conversely, larger institutions may exhibit greater operational complexity and systemic exposure. Controlling for size therefore reduces the risk that structural differences across banks are incorrectly attributed to ESG practices.

Bank size is measured as the natural logarithm of total assets. The logarithmic transformation reduces the influence of extreme differences in asset values and facilitates interpretation across banks of substantially different scales.

- **Exchange Rate**

The exchange rate is incorporated to capture common macroeconomic conditions affecting all sample banks over time. The study period, 2015–2024, witnessed substantial adjustments in the value of the Egyptian pound against the US dollar. These movements may influence foreign-currency assets and liabilities, external funding costs, borrowers' debt-servicing capacity, asset quality, profitability, liquidity, and capital adequacy.

Including the annual average EGP/USD exchange rate helps distinguish the estimated ESG effect from changes arising from the broader monetary environment. EXR is therefore treated strictly as a control variable rather than as the principal explanatory variable or a moderator of the ESG–stability relationship.

3.5. Econometric Specifications

The aggregate ESG index is mechanically constructed from its environmental, social, and governance components. Including the composite measure and its three pillars simultaneously would therefore generate severe multicollinearity and prevent the reliable identification of their individual coefficients. Accordingly, four separate models are estimated, each containing one sustainability measure together with the two control variables.

Model 1: Aggregate ESG Index

$$Z_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 Size_{it} + \beta_3 EXR_t + \varepsilon_{it}$$

Model 2: Environmental Dimension

$$Z_{it} = \beta_0 + \beta_1 E_{it} + \beta_2 Size_{it} + \beta_3 EXR_t + \varepsilon_{it}$$

Model 3: Social Dimension

$$Z_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 Size_{it} + \beta_3 EXR_t + \varepsilon_{it}$$

Model 4: Governance Dimension

$$Z_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 Size_{it} + \beta_3 EXR_t + \varepsilon_{it}$$

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where (ί) denotes the bank and (t) denotes the year. (ZScoreίt) represents financial stability, while (ESGίt), (Eίt), (Sίt), and (Gίt) denote the respective sustainability indicators. (Sizeit) is the natural logarithm of total assets, and (EXRt) is the annual average EGP/USD exchange rate. The term (β0) denotes the intercept; (β1) captures the effect of the sustainability measure under examination; and (β2) and (β3) are the coefficients on the control variables. Bank-specific unobserved heterogeneity is represented by (αi), while (είt) denotes the idiosyncratic error term.

Whether (αi) is treated as a fixed or random component is determined through the model-selection procedures described above. A full set of year fixed effects is not included concurrently with EXR because the exchange rate varies across years but not across banks within a given year. It would therefore be perfectly collinear with a complete set of annual indicators.

3.6. Sequence of Empirical Procedures

The empirical analysis follows a structured sequence beginning with data validation and preliminary analysis, followed by an assessment of the panel-data properties, model selection, diagnostic testing, robust estimation, and sensitivity analysis.

Table 3 Sequence of Econometric Tests and Procedures

Stage	Test or Procedure	Purpose
1	Data quality assessment	Verify completeness, identify missing or duplicate observations, and examine potential outliers
2	Descriptive statistics	Summarize the distribution and variability of the variables
3	Jarque–Bera and Shapiro–Wilk tests	Assess distributional properties
4	Pearson correlation matrix	Examine preliminary bivariate associations
5	Variance inflation factor and tolerance	Detect potentially harmful multicollinearity
6	Pesaran cross-sectional dependence test	Determine whether banks are jointly affected by common shocks
7	Panel unit-root tests	Assess the stationarity properties of the variables
8	Pooled OLS estimation	Provide a benchmark specification
9	Breusch–Pagan LM test	Compare pooled OLS with panel estimators
10	Hausman specification test	Discriminate between fixed-effects and random-effects estimators
11	Correlated random effects–Mundlak test	Evaluate the random-effects orthogonality assumption and support model selection
12	Modified Wald test	Test for groupwise heteroskedasticity
13	Wooldridge test	Test for serial correlation within panels
14	Residual Pesaran CD test	Detect cross-sectional dependence in model residuals
15	Entity-clustered robust standard errors	Obtain inference robust to within-bank dependence and heteroskedasticity

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16	CRE–Mundlak robustness analysis	Assess coefficient stability under an alternative specification
17	Economic significance analysis	Evaluate the substantive magnitude of the estimated effects

Following this sequence, the next section presents the sample, data sources, ESG-index construction, and preliminary data assessment before proceeding to the panel diagnostics, model-selection results, principal estimates, and robustness analysis.

4. Empirical Results

This section presents the empirical findings following the econometric framework outlined in the methodology. The analysis proceeds from preliminary data assessment and descriptive evidence to panel-data diagnostics, model selection, model estimation, robustness analyses, and the economic interpretation of the estimated relationships.

4.1. Data Preparation and Preliminary Assessment

Before estimating the econometric models, the study sample underwent a comprehensive preliminary assessment to verify its completeness, consistency, and overall suitability for panel-data analysis. This process involved checking for missing and duplicate observations, cross-validating all financial variables against the official published financial statements and annual reports, and screening for potentially influential outliers that could exert undue influence on the estimated coefficients.

The final sample consists of a balanced panel of 12 Egyptian banks observed over the period 2015–2024, yielding 120 bank-year observations. The validation process confirmed that the panel is complete, with no missing values or duplicate records. Moreover, all variables fall within economically plausible ranges consistent with their underlying accounting and financial definitions.

Potential outliers were identified using the interquartile range (IQR) criterion. The results indicate that the limited extreme observations reflect genuine economic differences across banks rather than recording or measurement errors. Consequently, no observations were removed or modified, and neither winsorization nor trimming procedures were applied, thereby preserving the genuine economic variation embedded in the data.

Table 4 Data Quality Assessment

Item	Result
Data structure	Balanced panel
Sample	12 Egyptian banks
Study period	2015–2024
Bank-year observations	120
Missing values	None
Duplicate observations	None
Influential outliers	None identified
Winsorization/Trimming	Not applied

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Note: Outliers were identified using the interquartile range (IQR) criterion. The limited extreme observations were retained because they represent genuine economic heterogeneity across banks rather than recording or measurement errors.

The results reported in Table 4 confirm the integrity of the analytical dataset. The balanced panel preserves both the cross-sectional and time-series dimensions of the sample without information loss. In addition, the absence of missing values and duplicate observations enhances the comparability of the data across banks and over time.

The IQR assessment further indicates that the few extreme observations represent legitimate cross-bank variation in size and financial performance rather than data anomalies. Accordingly, no observations were excluded or transformed, allowing the empirical analysis to retain the full extent of economically meaningful variation.

Overall, the preliminary assessment demonstrates that the dataset is internally consistent and methodologically sound, providing a reliable basis for the subsequent panel-data estimations and diagnostic procedures.

4.2. Preliminary Statistical Analysis

This section provides an initial statistical assessment of the study variables. It reports their distributional characteristics and pairwise associations and evaluates whether the explanatory variables included in each econometric specification exhibit problematic multicollinearity. These analyses provide descriptive context for the subsequent panel-data diagnostics and model estimation.

4.2.1. Descriptive Statistics

Table 5 reports the descriptive statistics for the variables used in the empirical analysis.

Table 5 Descriptive Statistics

Variable	Observations	Mean	Median	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
Z-score	120	24.819	23.410	9.629	10.958	51.457	0.661	2.709
ESG	120	25.017	27.000	5.361	12.000	30.000	−0.764	2.359
E	120	5.033	6.000	3.012	0.000	8.000	−0.481	1.643
S	120	8.567	9.000	1.909	2.000	10.000	−1.461	4.673
G	120	11.417	12.000	0.762	9.000	12.000	−1.102	3.417
Size	120	12.065	11.725	1.254	10.072	15.912	0.950	3.398
EXR	120	19.653	17.269	10.342	7.691	45.299	1.430	4.342

The Z-score has a mean of 24.819 and ranges from 10.958 to 51.457, indicating substantial heterogeneity in financial stability across banks and over time. Its mean slightly exceeds the median, while the moderate positive skewness reflects a limited number of observations with comparatively high stability levels.

The aggregate ESG score averages 25.017 out of a maximum of 30, equivalent to approximately 83.4% of the index ceiling. Its standard deviation of 5.361 nevertheless points to meaningful variation in sustainability practices within the sample. Among the three pillars, the environmental score exhibits the greatest relative dispersion, whereas governance displays limited variation and is concentrated near its upper bound. This restricted variation may reduce the statistical precision with which the governance effect is estimated.

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Bank size also varies appreciably across the sampled institutions. The exchange rate records pronounced dispersion, rising from 7.691 to 45.299 Egyptian pounds per US dollar during the sample period. This variation captures the considerable macroeconomic and currency adjustments experienced by Egypt between 2015 and 2024 and reinforces the relevance of controlling for common exchange-rate conditions.

Overall, the variables exhibit sufficient cross-sectional and temporal variation to support the panel estimations. The main exception is the comparatively compressed distribution of the governance score, which should be considered when interpreting its estimated coefficient and statistical significance.

4.2.2. Distributional Characteristics

The distributional characteristics of the variables were further examined using the Jarque–Bera and Shapiro–Wilk tests. The results are presented in Table 6.

Table 6 Normality Test Results

Variable	Observations	Jarque–Bera	p-value	Shapiro–Wilk	p-value	Decision at 5%
Z-score	120	9.051	0.010831	0.940	0.000040	Reject H_0
ESG	120	13.586	0.001122	0.849	<0.000001	Reject H_0
E	120	13.632	0.001096	0.829	<0.000001	Reject H_0
S	120	53.718	<0.000001	0.768	<0.000001	Reject H_0
G	120	24.294	0.000005	0.734	<0.000001	Reject H_0
Size	120	18.137	0.000115	0.928	0.000008	Reject H_0
EXR	120	47.529	<0.000001	0.777	<0.000001	Reject H_0

Note: H_0 denotes normality. A p-value below 0.05 indicates rejection of the null hypothesis.

Both tests reject normality for all variables at the 5% level. Departures from normality are particularly pronounced for the social score and the exchange rate, whereas the Z-score and bank size show comparatively milder deviations. These findings are consistent with the reported skewness and kurtosis and with the bounded nature of the ESG indicators.

Non-normality of the underlying variables does not preclude the use of fixed- or random-effects estimators. Statistical inference in the panel regressions depends more directly on the behavior of the disturbances and the adequacy of the estimated covariance matrix than on normality of the variables themselves. Accordingly, the data were neither transformed nor truncated on the basis of these tests. Subsequent inference relies on model-specific diagnostic procedures and bank-clustered robust standard errors.

4.2.3. Pearson Correlation Analysis

Table 7 presents the Pearson correlation coefficients among the study variables.

Table 7 Pearson Correlation Matrix

Variable	Z-score	ESG	E	S	G	Size	EXR
Z-score	1.000						
ESG	0.073	1.000					
E	0.080	0.969***	1.000				

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S	−0.017	0.955***	0.866***	1.000			
G	0.237***	0.812***	0.693***	0.789***	1.000		
Size	−0.108	0.565***	0.591***	0.497***	0.397***	1.000	
EXR	0.302***	0.498***	0.487***	0.436***	0.483***	0.352***	1.000

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The bivariate associations between financial stability and the sustainability indicators are generally modest. The aggregate ESG score and the environmental and social pillars are not significantly correlated with the Z-score. Governance, by contrast, is positively associated with financial stability at the 1% level. The exchange rate is also positively correlated with the Z-score, whereas bank size shows a small and statistically insignificant negative association.

As expected, the aggregate ESG score is strongly correlated with its constituent pillars. Its correlations with the environmental, social, and governance scores are 0.969, 0.955, and 0.812, respectively. These high coefficients largely reflect the mechanical construction of the composite index rather than independent economic relationships. For this reason, the aggregate measure and its dimensions are not entered jointly. Instead, the study estimates four separate specifications, each containing a single sustainability indicator.

Bank size and the exchange rate display moderate positive correlations with the ESG measures. These coefficients remain descriptive and should not be interpreted causally, as they do not control for unobserved bank heterogeneity, common time variation, or the other covariates included in the panel regressions. The correlation matrix therefore provides an initial account of the relationships among the variables but is not used as the definitive test of multicollinearity. Because the four sustainability measures do not enter the same regression, multicollinearity must be assessed within each model using the variance inflation factor.

4.2.4. Multicollinearity Assessment

Variance inflation factors and tolerance statistics were calculated separately for each of the four empirical specifications. Table 8 reports the results.

Table 8 Variance Inflation Factors and Tolerance Statistics

Model	Variable	VIF	Tolerance
Model 1: ESG	ESG	1.728	0.579
	Size	1.484	0.674
	EXR	1.342	0.745
Model 2: E	E	1.778	0.562
	Size	1.549	0.646
	EXR	1.322	0.757
Model 3: S	S	1.482	0.675
	Size	1.369	0.730
	EXR	1.273	0.785
Model 4: G	G	1.413	0.708
	Size	1.236	0.809
	EXR	1.358	0.736

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The VIF values range from 1.236 to 1.778, while the corresponding tolerance statistics lie between 0.562 and 0.809. These values are comfortably within conventional thresholds and provide no evidence of harmful multicollinearity in any specification.

This result also validates the decision to estimate the aggregate ESG index and its three pillars in separate models. Doing so avoids the mechanical collinearity that would arise from jointly including a composite measure and the variables from which it is constructed. No explanatory variable was therefore excluded, and no additional corrective procedure was required.

Taken together, the correlation and VIF results indicate that the explanatory variables entering each regression retain sufficient independent variation for stable coefficient estimation. The analysis can therefore proceed to the panel-data diagnostics and specification tests.

4.3. Panel-Data Diagnostics

This section examines the time-series and cross-sectional properties of the panel before model selection and estimation. The analysis first tests whether the sampled banks are exposed to common shocks. It then evaluates the stationarity of the variables using first-generation panel unit-root tests as an initial benchmark and the second-generation CIPS test as the primary diagnostic in the presence of cross-sectional dependence.

4.3.1. Cross-Sectional Dependence

The Pesaran cross-sectional dependence test was employed to determine whether the sampled banks evolve independently or respond jointly to common macroeconomic, regulatory, monetary, and market-wide shocks. The null hypothesis is cross-sectional independence. A p-value below 0.05 therefore indicates statistically significant dependence across banks.

Table 9 Pesaran Cross-Sectional Dependence Test

Variable	N	T	Valid pairs	CD statistic	p-value	Mean correlation	Mean absolute correlation	Decision at 5%
Z-score	12	10	66	5.971	<0.000001	0.232	0.451	Reject H_0
ESG	12	10	66	22.729	<0.000001	0.885	0.885	Reject H_0
E	12	10	66	20.374	<0.000001	0.793	0.793	Reject H_0
S	12	10	55	19.949	<0.000001	0.932	0.932	Reject H_0
G	12	10	45	13.650	<0.000001	0.779	0.779	Reject H_0
Size	12	10	66	22.260	<0.000001	0.866	0.866	Reject H_0

Note: H_0 denotes cross-sectional independence. With 12 banks, the maximum number of pairwise correlations is 66. The number of valid pairs is lower for the social and governance scores because some banks exhibit no time-series variation in these indicators, rendering the corresponding pairwise correlations undefined. EXR is excluded because it is a common macroeconomic series that assumes the same annual value for every bank; its cross-sectional dependence is therefore mechanical by construction.

The null of cross-sectional independence is rejected for every variable at the 1% level. Financial stability exhibits a mean pairwise correlation of 0.232 and a mean absolute

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correlation of 0.451. Dependence is substantially stronger for the sustainability indicators and bank size, with mean correlations ranging from 0.779 to 0.932.

These findings indicate that the sampled banks do not evolve as isolated entities. Rather, their financial and sustainability outcomes are jointly shaped by common economic conditions, regulatory developments, industry-wide practices, and other shared temporal influences. The particularly high dependence in ESG-related measures may also reflect the gradual sector-wide adoption of similar disclosure standards and sustainability practices.

The presence of cross-sectional dependence has an important econometric implication. First-generation panel unit-root tests, including LLC and IPS, are derived under cross-sectional independence and may therefore yield distorted evidence when common factors are present. Their results are consequently treated as preliminary benchmarks rather than definitive stationarity assessments. Greater weight is assigned to the second-generation CIPS test, which explicitly accommodates common cross-sectional influences.

4.3.2. First-Generation Panel Unit-Root Tests

As an initial assessment, stationarity was examined using the Levin–Lin–Chu and Im–Pesaran–Shin panel unit-root tests. The tests were first applied to the variables in levels and subsequently to their first differences whenever the level evidence was inconclusive or failed to reject the unit-root null.

Because EXR is identical across banks within each year, it cannot be treated as 12 independent cross-sectional series. Its ten unique annual observations were therefore examined separately using the augmented Dickey–Fuller test.

Table 10 Summary of First-Generation Unit-Root Test Results

Variable	Evidence at level	Evidence at first difference	Preliminary classification
Z-score	Conflicting LLC and IPS results	Stationary under both tests	Not established as stationary in levels; stationary after first differencing
ESG	Stationary under both tests	Stationary	I(0)
E	Conflicting LLC and IPS results	Stationary under both tests	Not established as stationary in levels; stationary after first differencing
S	Stationary under both tests	Stationary	I(0)
G	Stationary under both tests	Stationary	I(0)
Size	Non-stationary under both tests	Stationary under both tests	I(1)
EXR	Unit-root null not rejected by ADF	Unit-root null not rejected after first differencing	Inconclusive because of the short series and structural shifts

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Note: The null hypothesis in the LLC, IPS, and ADF tests is the presence of a unit root. A conservative classification is adopted when LLC and IPS produce conflicting evidence: a variable is not classified as level-stationary unless both tests reject the unit-root null.

The first-generation results classify the aggregate ESG index and the social and governance pillars as stationary in levels. By contrast, the evidence for the Z-score and environmental score is mixed at level, although both become stationary after first differencing. Bank size is consistently non-stationary in levels and stationary in first differences, suggesting a persistent upward trend over the sample period. For the exchange rate, the ADF test does not reject the unit-root null either in levels or after first differencing. This result should be interpreted with considerable caution. The test is based on only ten annual observations and thus has very limited power. Moreover, the Egyptian pound underwent major exchange-rate regime adjustments and abrupt depreciations between 2015 and 2024. Conventional unit-root tests that do not accommodate structural breaks may consequently fail to distinguish persistent regime shifts from a stochastic unit-root process. Overall, the first-generation tests point to heterogeneous integration properties across the variables. However, because the preceding analysis documents strong cross-sectional dependence, these findings cannot serve as the final basis for determining stationarity. The second-generation CIPS test is therefore used to provide evidence that is more consistent with the observed structure of the panel.

4.3.3. Second-Generation Panel Unit-Root Test

Given the rejection of cross-sectional independence, the Pesaran cross-sectionally augmented IPS test was applied to the bank-level variables. CIPS augments the individual unit-root regressions with cross-sectional averages and is therefore better suited to panels affected by common factors. In view of the short time dimension of the sample, the test was estimated with an intercept and no additional lagged differences to preserve degrees of freedom. EXR was excluded because it is a common annual series rather than a set of independently varying bank-level observations.

Table 11 Comparison of First- and Second-Generation Panel Unit-Root Evidence

Variable	LLC and IPS at level	CIPS at level	Conservative assessment
Z-score	Mixed evidence	Stationarity not established	Stationarity not established in levels
ESG	Stationary	Stationarity not established	Stationarity not established in levels
E	Mixed evidence	Stationarity not established	Stationarity not established in levels
S	Stationary	Stationary	Level-stationary, I(0)
G	Stationary	Not stationary at 5%	Stationarity not established at the 5% level
Size	Non-stationary	Stationarity not established	Stationarity not established in levels

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Note: The number of valid cross-sectionally augmented Dickey–Fuller regressions is lower for the social and governance indicators because some banks report constant scores throughout the sample period. When first- and second-generation tests yield different conclusions, greater weight is assigned to CIPS because cross-sectional dependence has been established empirically.

The social pillar is the only variable for which both generations of tests provide consistent evidence of level stationarity. CIPS does not establish level stationarity for the Z-score, aggregate ESG index, environmental score, or bank size. Governance also fails to reject the unit-root null at the 5% level, although weaker evidence of stationarity is observed at the 10% threshold.

The comparison demonstrates why reliance on LLC and IPS alone would produce an overly optimistic assessment of the stationarity of the aggregate ESG and governance measures. Once common cross-sectional factors are incorporated, the evidence of level stationarity becomes substantially weaker.

These results must nevertheless be interpreted in light of the panel's limited time dimension and the bounded, discrete nature of the sustainability scores. Both features reduce the power of panel unit-root tests. Failure to reject the unit-root null should therefore not be treated as conclusive proof of non-stationarity.

Nor does the CIPS evidence necessarily justify mechanically differencing every variable. Such a transformation would alter the underlying research question from whether the levels of sustainability practices are associated with bank stability to whether annual changes in those practices affect annual changes in stability. Given the theoretical focus of the study, the principal models are therefore estimated in levels, while the stationarity evidence is acknowledged as a limitation and alternative transformations are considered in the robustness analysis. The resulting coefficients should accordingly be interpreted as conditional associations rather than long-run equilibrium or causal effects.

4.4. Model Specification and Estimator Selection

This section determines the appropriate estimator for each empirical specification. Pooled ordinary least squares is first reported as an unrestricted benchmark. The Breusch–Pagan Lagrange multiplier test then evaluates whether unobserved bank-level effects warrant a panel estimator. Conditional on that result, the Hausman and correlated random effects–Mundlak tests assess whether those effects are systematically related to the explanatory variables.

4.4.1. Benchmark Pooled OLS Estimation

Pooled OLS estimates were obtained as an initial benchmark before accounting for unobserved bank heterogeneity. Consistent with the empirical design, four separate regressions were estimated, each including either the aggregate ESG index or one of its constituent pillars together with bank size and the exchange rate.

Table 12 Benchmark Pooled OLS Estimates

Variables	Model 1: ESG	Model 2: E	Model 3: S	Model 4: G
ESG	0.0545	—	—	—
	(0.2028)			

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Variables	Model 1: ESG	Model 2: E	Model 3: S	Model 4: G
E	—	0.1997	—	—
		(0.3657)		
S	—	—	−0.4837	—
			(0.5256)	
G	—	—	—	2.6167**
				(1.2665)
Size	−1.9838**	−2.1097**	−1.5913**	−2.2923***
	(0.8036)	(0.8201)	(0.7693)	(0.7205)
EXR	0.3521***	0.3432***	0.3884***	0.2862***
	(0.0926)	(0.0918)	(0.0899)	(0.0915)
Constant	40.4693***	42.5210***	40.5287***	16.9768
	(8.1134)	(8.9901)	(8.0827)	(13.8522)
Observations	120	120	120	120
R^2	0.1445	0.1461	0.1501	0.1743
Adjusted R^2	0.1223	0.1241	0.1282	0.1530
F-statistic	6.5295	6.6175	6.8310	8.1635
p-value of F-statistic	0.0004	0.0004	0.0003	0.0001

Note: The dependent variable is the Z-score. Conventional standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The aggregate ESG measure and its constituent pillars are estimated separately to avoid mechanical multicollinearity.

The benchmark estimates provide a preliminary view of the relationships in the pooled sample. The coefficients on aggregate ESG, the environmental pillar, and the social pillar are statistically insignificant. Governance is positively associated with the Z-score at the 5% level and produces the highest R^2 among the four specifications, although the differences in explanatory power are modest.

The control variables display a stable pattern. Bank size is negatively associated with financial stability in every specification, whereas the exchange rate enters positively and is significant at the 1% level throughout. All four regressions are jointly significant, with R^2 values ranging from 0.145 to 0.174.

These estimates are not used for hypothesis testing because pooled OLS imposes homogeneity across banks and disregards time-invariant unobserved institutional characteristics. The conventional standard errors reported in Table 4.9 also do not accommodate the dependence structure identified in the preceding diagnostics. The pooled results therefore serve only as a benchmark against which the panel estimates are subsequently evaluated.

4.4.2. Breusch–Pagan Lagrange Multiplier Test

The Breusch–Pagan Lagrange multiplier test was applied separately to the four specifications to determine whether unobserved bank-specific effects are statistically distinguishable from zero. The null hypothesis is that the variance of the individual effect equals zero, in which case pooled OLS is adequate. Rejection favors a panel estimator over the pooled specification.

Table 13 Breusch–Pagan Lagrange Multiplier Test

Model	Banks (N)	Years (T)	LM statistic	df	p-value	Decision	Implication
Model 1: ESG	12	10	214.488	1	<0.000001	Reject H_0	Panel estimator preferred
Model 2: E	12	10	217.227	1	<0.000001	Reject H_0	Panel estimator preferred
Model 3: S	12	10	199.663	1	<0.000001	Reject H_0	Panel estimator preferred
Model 4: G	12	10	197.275	1	<0.000001	Reject H_0	Panel estimator preferred

Note: The test is based on the residuals from the corresponding pooled OLS regression. H_0 states that there is no statistically significant bank-specific effect.

The null is rejected at the 1% level in all four specifications. The results provide strong evidence of persistent unobserved heterogeneity across banks and reject the homogeneous-intercept assumption imposed by pooled OLS. Panel estimators are therefore more appropriate for the data.

The LM test does not, however, determine whether the unobserved effects are correlated with the regressors. It establishes the relevance of the panel structure but cannot distinguish between fixed and random effects. That choice is examined using the Hausman specification test.

4.4.3. Hausman Specification Test

The Hausman test compares fixed- and random-effects estimates by examining whether the unobserved bank-specific component is orthogonal to the explanatory variables. Under the null, both estimators are consistent, but random effects are more efficient. Rejection indicates that the random-effects orthogonality condition is violated and favors fixed effects.

Table 14 Hausman Specification Test

Model	Hausman statistic	df	p-value	Decision at 5%	Indicated estimator
Model 1: ESG	5.832	3	0.1201	Do not reject H_0	Random effects
Model 2: E	5.278	3	0.1526	Do not reject H_0	Random effects
Model 3: S	6.566	3	0.0871	Do not reject H_0	Random effects
Model 4: G	8.320	3	0.0398	Reject H_0	Fixed effects

Note: H_0 states that the unobserved bank-specific effects are uncorrelated with the regressors. Failure to reject supports random effects, whereas rejection favors fixed effects.

The test does not reject the null for the aggregate ESG, environmental, or social specifications at the 5% level, indicating random effects. For the social model, however, the p-value of 0.0871 is relatively close to conventional significance thresholds and constitutes weaker evidence against the random-effects assumption at the 10% level.

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For governance, the null is rejected at the 5% level, indicating a systematic association between the regressors and unobserved bank characteristics and therefore favoring fixed effects. The results suggest that the appropriate treatment of bank-specific heterogeneity is not necessarily uniform across the four sustainability measures.

Because the conventional Hausman test can be sensitive to covariance-matrix estimation and finite-sample conditions, the specification choice is further examined using the correlated random effects–Mundlak approach.

4.4.4. Correlated Random Effects–Mundlak Assessment

The Mundlak approach provides a complementary assessment of the random-effects orthogonality assumption. It augments each random-effects specification with bank-level time averages of the time-varying regressors. Their joint significance indicates that the unobserved individual effect is correlated with the explanatory variables and that the conventional random-effects restriction is untenable.

The time mean of EXR was excluded because the exchange rate varies only over time and is identical across banks in each year. Including its bank-specific mean would therefore add no cross-sectional information.

Table 15 Correlated Random Effects–Mundlak Test

Model	Wald statistic	df	p-value	Decision at 5%	Implication
Model 1: ESG	5.925	2	0.0517	Do not reject H_0	Conventional RE not rejected
Model 2: E	5.458	2	0.0653	Do not reject H_0	Conventional RE not rejected
Model 3: S	6.568	2	0.0375	Reject H_0	Correlated effects indicated
Model 4: G	4.847	2	0.0886	Do not reject H_0	Conventional RE not rejected

Note: H_0 states that the coefficients on the bank-level time means are jointly equal to zero. Rejection indicates correlation between the unobserved bank effect and at least one time-varying regressor.

For the aggregate ESG and environmental specifications, Mundlak does not reject the conventional random-effects restriction at the 5% level, consistent with the Hausman results. The corresponding p-values of 0.0517 and 0.0653 are nevertheless close to the threshold and should not be interpreted as unequivocal evidence of orthogonality.

The two tests yield different conclusions for the social and governance models. In the social specification, Hausman does not reject random effects at 5%, whereas Mundlak identifies statistically significant correlated effects. In the governance model, Hausman favors fixed effects, while the Mundlak restriction is not rejected. These discrepancies indicate that estimator selection for S and G is sensitive to the specification test employed.

Accordingly, the evidence supports a relatively clear random-effects specification for the aggregate ESG and environmental models but is less decisive for the social and governance pillars. The principal estimator for each model is selected conservatively by considering the test evidence jointly, the economic structure of the regressors, and the consistency of the resulting estimates. Alternative fixed-effects, random-effects, and correlated random-effects estimates are retained as robustness checks rather than treating any single specification test as conclusive.

On balance, the main analysis employs random effects for the aggregate ESG, environmental, and social specifications and fixed effects for governance, in line with the primary Hausman classification. The social model is interpreted cautiously because Mundlak detects correlated heterogeneity, while the governance results are evaluated against the corresponding random-effects and CRE estimates in the robustness analysis. All final models use covariance estimators suited to the diagnosed error structure.

4.5. Post-Estimation Diagnostic Tests

Following the selection of the appropriate panel-data specification for each model, a series of post-estimation diagnostic tests was conducted to assess whether the underlying assumptions required for reliable statistical inference were satisfied. Specifically, the analysis examined groupwise heteroskedasticity, first-order serial correlation, and residual cross-sectional dependence. The outcomes of these diagnostics provide the basis for the inference procedure adopted in the final estimations.

4.5.1. Modified Wald Test for Groupwise Heteroskedasticity

Following model selection, the Modified Wald test was employed to examine the null hypothesis of homoskedastic disturbances across cross-sectional units. Consistent with the standard implementation of the test, the procedure was performed separately for each specification using the residuals obtained from the fixed-effects estimator.

Table 16 Modified Wald Test for Groupwise Heteroskedasticity

Model	Banks (N)	Years (T)	χ^2 Statistic	Degrees of Freedom	p-value	Decision (5%)	Conclusion
Model (1): ESG	12	10	224.958	12	<0.000001	Reject H_0	Groupwise heteroskedasticity detected
Model (2): E	12	10	453.472	12	<0.000001	Reject H_0	Groupwise heteroskedasticity detected
Model (3): S	12	10	215.509	12	<0.000001	Reject H_0	Groupwise heteroskedasticity detected
Model (4): G	12	10	98.031	12	<0.000001	Reject H_0	Groupwise heteroskedasticity detected

Notes: The Modified Wald test was performed separately for each specification using fixed-effects residuals. The null hypothesis assumes homoscedastic error variances across cross-sectional units. Rejection of the null hypothesis indicates the presence of group wise heteroskedasticity.

The results uniformly reject the null hypothesis at the 1% significance level, indicating the presence of group wise heteroskedasticity in all four specifications. Consequently, the assumption of constant error variance is violated, implying that conventional standard errors may yield unreliable statistical inference despite the consistency of the coefficient estimates.

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These findings therefore justify the use of heteroskedasticity-robust inference in the subsequent estimations. Nevertheless, heteroskedasticity alone does not fully characterize the stochastic properties of the error term. The remaining assumptions are examined through the Wooldridge test for serial correlation.

4.5.2. Wooldridge Test for First-Order Serial Correlation

To examine whether the regression disturbances exhibit first-order serial correlation within banks, the Wooldridge test for panel-data models was performed for each empirical specification. Owing to its robustness to heteroskedasticity and its suitability for short panel datasets, the Wooldridge test is widely regarded as the standard diagnostic for detecting within-panel serial correlation.

Table 17 Wooldridge Test for First-Order Serial Correlation

Model	Banks (N)	Years (T)	F Statistic	Degrees of Freedom	p-value	Decision (5%)
Model (1): ESG	12	10	6.6220	(1, 11)	0.0259	Reject H_0
Model (2): E	12	10	5.7202	(1, 11)	0.0358	Reject H_0
Model (3): S	12	10	6.6976	(1, 11)	0.0252	Reject H_0
Model (4): G	12	10	7.3509	(1, 11)	0.0202	Reject H_0

Notes: The Wooldridge test was performed separately for each model to detect first-order serial correlation in the idiosyncratic error term. The null hypothesis assumes the absence of first-order serial correlation. Rejection of the null hypothesis indicates that the regression disturbances are serially correlated within cross-sectional units.

The Wooldridge test rejects the null hypothesis for all four model specifications at the 5% significance level, indicating the presence of first-order serial correlation within individual banks. Under these conditions, conventional covariance estimators may underestimate sampling variability, resulting in overly optimistic statistical inference.

The presence of serial correlation does not, however, imply that a dynamic panel specification is required. The objective of the present study is to estimate the contemporaneous relationship between sustainability practices and financial stability rather than dynamic persistence in bank stability. Moreover, the theoretical framework does not posit a lagged dependent variable, and the empirical specification was not designed to estimate dynamic adjustment processes. Accordingly, correcting the covariance matrix using bank-clustered robust standard errors provides an appropriate and sufficient solution for valid statistical inference.

The remaining diagnostic step examines whether residual cross-sectional dependence persists after controlling for the observed explanatory variables and unobserved bank-specific heterogeneity.

4.5.3. Residual Cross-Sectional Dependence Test

Although the preliminary Pesaran CD tests identified cross-sectional dependence in several study variables, the primary concern for statistical inference is whether such dependence persists in the regression residuals after controlling for the explanatory variables and the selected bank-specific effects. Accordingly, the Pesaran CD test was re-applied to the residuals of the final estimated models.

To verify that the results were not driven by the choice of estimator, the diagnostic was also performed under both the fixed-effects and random-effects specifications for models in which the Hausman and CRE–Mundlak procedures suggested alternative estimators. This additional assessment provides further evidence regarding the robustness of the estimated specifications.

Table 18 Pesaran CD Test for Residual Cross-Sectional Dependence

Model	Estimator	Average Correlation	Median Correlation	CD Statistic	p-value	Decision (5%)
Model (1): ESG	RE	−0.0100	0.0173	−0.2568	0.7973	Fail to Reject H_0
Model (2): E	RE	−0.0166	0.0264	−0.4270	0.6694	Fail to Reject H_0
Model (3): S	RE	0.0116	0.0130	0.2976	0.7660	Fail to Reject H_0
Model (4): G	FE	0.0407	0.0717	1.0447	0.2961	Fail to Reject H_0

Notes: The Pesaran CD test was applied to the residuals of the final estimated models to examine whether cross-sectional dependence remained after accounting for the explanatory variables and bank-specific effects. The null hypothesis assumes cross-sectional independence of the regression residuals. Failure to reject the null hypothesis indicates that no statistically significant residual cross-sectional dependence is present.

As reported in Table 18, the null hypothesis cannot be rejected for any of the four model specifications, with all p-values substantially exceeding the conventional 5% significance level. These results indicate that no statistically significant cross-sectional dependence remains in the regression residuals once the explanatory variables and the selected bank-specific effects have been incorporated into the empirical models.

This finding is fully consistent with, rather than contradictory to, the preliminary diagnostic results reported earlier. Whereas the initial Pesaran CD tests assessed cross-sectional dependence in the observed variables, the present analysis evaluates whether any unexplained cross-sectional correlation persists after model estimation. The absence of residual dependence therefore indicates that the selected model specifications adequately capture the common variation shared across banks, leaving no evidence of systematic cross-sectional dependence in the remaining disturbances.

Furthermore, replicating the diagnostic under alternative panel estimators produced qualitatively identical conclusions, indicating that the results are robust to the choice of estimation framework and are not driven by estimator selection.

Taken together, the post-estimation diagnostic tests reveal the presence of groupwise heteroskedasticity and within-bank serial correlation, while providing no evidence of statistically significant residual cross-sectional dependence. Accordingly, all subsequent regression results are reported using bank-clustered robust standard errors to ensure reliable statistical inference. The empirical estimation results are presented in the following section.

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4.6. Main Estimation Results

Following the diagnostic evaluation and confirmation of the appropriate panel-data specifications, four benchmark regression models were estimated to examine the relationship between sustainability practices and the financial stability of Egyptian banks over the 2015–2024 period. The first model evaluates the effect of the overall ESG score, whereas the remaining three models separately assess the Environmental (E), Social (S), and Governance (G) dimensions. Estimating each sustainability indicator independently avoids potential multicollinearity between the composite index and its constituent dimensions while allowing the incremental contribution of each pillar to be identified.

Consistent with the model selection procedures reported in the preceding section, Models (1)–(3) are estimated using the random-effects estimator, whereas Model (4) is estimated using fixed effects. To ensure valid statistical inference, all reported standard errors are corrected using bank-clustered robust covariance estimators.

4.6.1. Overall Estimation Results

Table 19 presents the benchmark estimation results for the four panel regression models.

Table 19 Baseline Panel Regression Results

Variable	Model (1) ESG	Model (2) E	Model (3) S	Model (4) G
ESG	0.4562**	—	—	—
	(0.2176)			
E	—	0.8858**	—	—
		(0.3841)		
S	—	—	0.8497	—
			(0.7250)	
G	—	—	—	1.7695*
				(0.9945)
Size	−6.2908***	−6.3539***	−5.5850***	−7.1129***
	(2.1264)	(2.2233)	(1.9575)	(2.6687)
EXR	0.4322***	0.4270***	0.4514***	0.5220***
	(0.1032)	(0.1008)	(0.1107)	(0.1301)
Constant	80.8078***	88.6279***	76.0507***	—
	(22.3218)	(24.6737)	(21.4516)	
Model Specification	Random Effects	Random Effects	Random Effects	Fixed Effects
Overall R^2	0.3412	0.3476	0.3196	0.3505
Within R^2	0.3767	0.3821	0.3545	0.3505
Robust Wald/F Statistic	6.7023	6.6450	6.6143	6.4411
Prob. > Wald/F	0.0003	0.0004	0.0004	0.0005
Observations	120	120	120	120
Banks	12	12	12	12

Notes: The dependent variable is the Financial Stability Index (Z-Score). Bank-clustered robust standard errors are reported in parentheses. Models (1)–(3) are estimated using random effects, whereas Model (4) is estimated using fixed effects, as determined by the specification tests reported in Section 4.5. Statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% levels, respectively.

Table 19 reveals that the effect of sustainability practices on financial stability varies across the different ESG dimensions. The overall ESG index exhibits a positive and statistically significant coefficient, indicating that stronger sustainability performance is associated with higher financial stability. A similarly positive and statistically significant relationship is observed for the environmental dimension, which provides the strongest empirical support among the individual ESG pillars.

By contrast, the governance dimension remains positively associated with financial stability but achieves only marginal statistical significance at the 10% level. The social dimension also carries a positive coefficient; however, its effect is not statistically distinguishable from zero, suggesting that its independent contribution to financial stability cannot be confirmed within the study period.

The estimated coefficients of the control variables remain remarkably stable across all specifications. Bank size consistently exerts a negative and highly significant effect, whereas the exchange rate maintains a positive and highly significant association with financial stability regardless of the sustainability measure employed. The persistence of these effects across alternative model specifications reinforces the stability of the estimated relationships.

The models also exhibit comparable explanatory power, with Overall R^2 values ranging from 0.320 to 0.351 and all specifications remaining jointly significant according to the robust Wald/F statistics. Collectively, these findings indicate that sustainability contributes to financial stability, although its influence differs substantially across the individual ESG dimensions. This evidence provides the basis for evaluating the economic magnitude of these relationships in the following section.

4.6.2. Economic Significance of the Estimated Effects

Statistical significance alone does not necessarily imply economic relevance. Regression coefficients may differ substantially in their practical implications because the explanatory variables vary in scale and dispersion. Accordingly, the economic significance of the estimated sustainability effects is evaluated by quantifying the expected change in financial stability associated with a one-standard-deviation increase in each sustainability indicator. To facilitate direct comparison across the ESG measures, the estimated effects are further expressed as a percentage of the sample mean of the Financial Stability Index (Z-Score) and reported alongside standardized effect sizes.

Table 20 Economic Significance of the Estimated Sustainability Effects

Variable	Coefficient	Standard Deviation	Expected Effect on Z-Score	% of Mean Z-Score	Standardized Effect	Statistical Significance
ESG	0.4562	5.361	2.446	9.85%	0.254	5%
E	0.8858	3.012	2.668	10.75%	0.277	5%
S	0.8497	1.909	1.622	6.54%	0.168	Not Significant
G	1.7695	0.762	1.348	5.43%	0.140	10%

Notes: The expected effect is calculated as the product of the estimated regression coefficient and one standard deviation of the corresponding sustainability indicator. The percentage expresses the estimated change

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relative to the sample mean of the Financial Stability Index (Z-Score). Standardized effects provide a scale-independent measure for comparing the relative economic importance of the sustainability indicators.

The results indicate that the relative economic importance of the sustainability dimensions differs from what may be inferred solely from the estimated regression coefficients. Once differences in the dispersion of the explanatory variables are taken into account, the environmental dimension emerges as the economically most influential sustainability measure, followed closely by the aggregate ESG index. A one-standard-deviation improvement in environmental performance is associated with an expected increase in financial stability equivalent to **10.75%** of the sample mean of the Z-Score, compared with **9.85%** for the overall ESG index.

Although the governance dimension reports the largest unstandardized coefficient, its relatively limited variation across banks substantially reduces its standardized economic contribution. Consequently, its practical effect is smaller than that of both the environmental dimension and the aggregate ESG index. Likewise, the social dimension exhibits a moderate standardized effect but remains statistically insignificant, suggesting that its estimated economic contribution should be interpreted with caution.

Overall, the standardized estimates establish a clear ranking in the relative economic importance of the sustainability indicators:E>ESG>S>G

This ranking highlights that the contribution of sustainability to financial stability is not evenly distributed across its underlying dimensions. Instead, environmental practices account for the largest economically meaningful improvement in bank stability, whereas governance and social initiatives exhibit comparatively smaller marginal contributions within the study sample. These findings complement the statistical evidence presented in the previous section and provide a more comprehensive assessment of the practical relevance of sustainability performance.

4.6.3. Synthesis of the Empirical Findings

The empirical evidence presented in the preceding sections reveals a consistent pattern regarding the relationship between sustainability practices and financial stability. Rather than exerting a uniform influence, the individual ESG dimensions contribute to bank stability to varying degrees, indicating that the aggregate sustainability index masks substantial heterogeneity across its underlying components.

Among the three dimensions, environmental performance provides the strongest and most consistent evidence of a positive association with financial stability. This finding is supported by both the statistical estimates and the economic significance analysis, suggesting that environmental initiatives represent the sustainability pillar with the greatest practical relevance for strengthening bank resilience. The aggregate ESG index likewise exhibits a stable positive relationship, indicating that a comprehensive commitment to sustainability is associated with more resilient financial performance.

The governance dimension also contributes positively to financial stability, although its influence appears comparatively weaker and less precisely estimated. By contrast, the social dimension does not exhibit an independent statistically significant effect within the study period, implying that its contribution may operate indirectly or emerge over a longer horizon than that captured in the present analysis.

Taken together, these findings demonstrate that sustainability should not be viewed as a homogeneous construct. Although the composite ESG index provides useful evidence regarding the overall role of sustainability, examining its underlying dimensions separately yields substantially richer insights into the mechanisms through which sustainability contributes to financial stability. The heterogeneous effects identified across the ESG pillars therefore justify the modelling strategy adopted in this study and highlight the importance of disaggregating composite sustainability measures in empirical banking research.

The next section builds on these empirical findings by examining their consistency under an alternative estimation framework as part of the robustness analysis.

4.7. Robustness Analysis: Correlated Random Effects (CRE–Mundlak) Estimation

To evaluate whether the empirical findings are sensitive to the choice of panel-data specification, an additional robustness analysis was conducted using the Correlated Random Effects (CRE–Mundlak) estimator. Unlike the conventional random-effects model, the CRE specification explicitly accommodates potential correlation between the unobserved bank-specific effects and the explanatory variables by augmenting the model with the time averages of the regressors. This framework combines the efficiency advantages of random effects with the flexibility of fixed effects and has consequently become one of the standard robustness procedures in contemporary panel-data research.

Accordingly, all four benchmark models were re-estimated using the CRE–Mundlak approach with bank-clustered robust standard errors. The objective is to assess whether the principal empirical conclusions remain stable under a more general specification that relaxes the strict exogeneity assumption underlying the conventional random-effects estimator.

Table 21 Robustness Analysis Using the Correlated Random Effects (CRE–Mundlak) Estimator

Variable	Model (1) ESG	Model (2) E	Model (3) S	Model (4) G
ESG	0.5417**	—	—	—
	(0.2344)			
E	—	1.0141**	—	—
		(0.4345)		
S	—	—	1.0847	—
			(0.7011)	
G	—	—	—	1.7695*
				(1.0075)
Size	−8.2852***	−8.2086***	−7.5357***	−7.1129***
	(2.8020)	(2.9011)	(2.5368)	(2.7035)
EXR	0.4953***	0.4879***	0.5157***	0.5220***
	(0.1188)	(0.1175)	(0.1261)	(0.1318)
Overall R^2	0.3737	0.3779	0.3533	0.3421
Observations	120	120	120	120

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Notes: The dependent variable is the Financial Stability Index (Z-Score). Bank-clustered robust standard errors are reported in parentheses. Statistical significance is denoted by ***, **, and * at the 1%, 5%, and 10% levels, respectively.

The CRE–Mundlak estimates closely mirror the benchmark results reported in the previous section. Across all four specifications, the estimated coefficients preserve their original signs, while their magnitudes remain broadly comparable. More importantly, the statistical significance of the principal variables is unaffected by the alternative estimation strategy.

Specifically, both the aggregate ESG index and the environmental dimension continue to exhibit positive and statistically significant effects at the 5% level. The social dimension remains positive but statistically insignificant, whereas the governance dimension retains a positive coefficient that remains significant at the 10% level. The consistency of these findings indicates that the estimated sustainability effects are not driven by the particular panel estimator adopted in the baseline analysis.

The control variables display a similarly stable pattern. Bank size continues to exert a negative and highly significant influence across all specifications, while the exchange rate remains positively associated with financial stability at the 1% significance level. Although modest differences in coefficient magnitude are observed, these variations do not alter the substantive interpretation of the estimated relationships.

Overall, the robustness analysis provides strong evidence that the study's principal conclusions are insensitive to the choice of panel-data estimator. The consistency observed in the direction, magnitude, and statistical significance of the estimated effects indicates that the documented relationship between sustainability practices and financial stability reflects a stable empirical pattern rather than an artefact of model specification. Taken together with the specification tests and post-estimation diagnostics, these results strengthen confidence in the reliability and credibility of the empirical findings reported in this study.

5. Discussion

This section interprets the empirical findings in relation to the study’s theoretical framework, the institutional features of the Egyptian banking sector, and the existing international evidence. Rather than restating the regression results, the discussion focuses on the economic mechanisms underlying the estimated relationships and on the extent to which the findings confirm, qualify, or depart from earlier research.

5.1. The Overall ESG Effect

The positive and statistically significant association between the aggregate ESG index and bank financial stability indicates that sustainability practices have become economically relevant to the resilience of Egyptian banks. Banks with stronger sustainability performance appear better positioned to absorb adverse shocks and preserve financial soundness, even after controlling for bank size and exchange-rate conditions. This result suggests that ESG engagement is no longer confined to regulatory compliance or corporate responsibility; it increasingly forms part of the broader architecture through which banks manage risk, protect stakeholder confidence, and sustain institutional resilience.

Several channels may explain this relationship. Stronger ESG performance can improve risk identification and monitoring, reinforce internal oversight, and promote more transparent disclosure. It may also strengthen relationships with depositors, investors, customers, regulators, and other stakeholders, thereby reducing reputational and operational vulnerabilities. These benefits are particularly relevant in banking, where confidence, information quality, and prudent risk governance are central to financial stability. From this perspective, the estimated effect captures not only the direct influence of individual sustainability practices but also the cumulative value of embedding environmental, social, and governance considerations within strategic and operational decision-making.

The finding is consistent with the prevailing evidence reported by (Pyka, Karkowska, & Nocoń, 2025); (Almulla, Albaity, & Al-Tamimi, 2025); (Choi, Ryu, & You, 2024), (Sassi & Lassoued, 2026); (Aburasul, Abd Rahman, Al-Qudah, Alanazi, & Alnaim, 2025), who consistently document that stronger ESG performance enhances bank resilience through improved risk management, governance quality, and reduced financial constraints. The evidence is also aligned with (Hamidjaya & Danarsari, 2026), who show that sustainability practices mitigate the consequences of economic shocks and enhance financial stability in volatile environments. Likewise, (Mirza, Umar, Lobont, & Safi, 2025) demonstrate that ESG-oriented lending improves risk-adjusted returns and reduces non-performing loans, thereby strengthening financial stability through enhanced asset quality and more prudent lending decisions.

However, the result differs from Chouaibi and Ali Ben (2026), who report that the aggregate ESG effect may be negative or unstable under certain institutional conditions. Such divergence is not unexpected, as the financial consequences of ESG practices are likely to depend on regulatory quality, market development, disclosure standards, and the maturity of sustainability integration. In jurisdictions where ESG initiatives are largely symbolic, weakly monitored, or costly to implement, their financial benefits may be limited or delayed. Conversely, where regulatory pressure and institutional capacity encourage substantive adoption, sustainability practices are more likely to strengthen risk management and resilience.

The Egyptian setting provides a plausible explanation for the positive relationship identified in this study. During the sample period, the banking sector experienced a gradual expansion in sustainable-finance practices, risk-governance requirements, and sustainability-related disclosure. These developments may have increased the strategic value of ESG integration by encouraging banks to align lending, governance, and risk-management processes with wider regulatory and developmental priorities. Accordingly, the estimated effect may reflect not only bank-level initiatives but also the progressive institutionalisation of sustainability within the Egyptian banking system. This interpretation is further supported by (Abbas & Abdel Megid, 2025), who report that stronger ESG disclosure among Egyptian banks is associated with more favourable institutional and financial characteristics, providing additional evidence that sustainability practices have become increasingly integrated into the Egyptian banking sector.

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The result also supports stakeholder theory. By addressing the interests of regulators, customers, employees, investors, and society, banks may reduce stakeholder-related risks and strengthen the legitimacy and durability of their operations. In this sense, ESG performance contributes to financial stability because it improves the quality of the relationships on which banking activity depends. The finding therefore extends the application of stakeholder theory to bank resilience by showing that responsible engagement with multiple constituencies can generate measurable financial-stability benefits.

Overall, the evidence indicates that aggregate ESG performance represents a meaningful determinant of bank stability in an emerging-market context. Nevertheless, the composite result does not imply that all sustainability dimensions contribute equally. The separate estimates for the environmental, social, and governance pillars reveal substantial heterogeneity, which is examined in the following subsections.

5.2. The Environmental Dimension

Among the three ESG pillars, the environmental dimension exhibits the strongest contribution to financial stability, both statistically and economically. The findings indicate that environmental performance is the principal driver of the positive relationship observed between sustainability practices and bank resilience, suggesting that investments in environmental initiatives generate tangible financial benefits beyond their regulatory or reputational value.

A plausible explanation lies in the growing integration of environmental considerations into banks' risk-management frameworks. Environmental practices can improve the identification and assessment of climate-related, transition, and environmental risks while supporting more prudent credit allocation and long-term portfolio quality. As banks become increasingly exposed to sustainability-related financial risks, incorporating environmental criteria into lending and investment decisions may enhance asset quality, strengthen institutional resilience, and reduce vulnerability to future shocks.

This interpretation is consistent with the evidence reported by (Choi, Ryu, & You, 2024), (Işık, Zolfani, Shabir, & Šaparauskas, 2025), (Sassi & Lassoued, 2026); (Magazzino, Arnone, Leogrande, & Gattone, 2026), who conclude that stronger environmental performance contributes to improved risk management and greater financial stability. Similarly, (Palmieri, Polato, & Floreani, 2025) argue that environmental initiatives, particularly those associated with sustainable finance and green financial instruments, can improve asset quality and indirectly reduce credit risk, thereby reinforcing banking-sector resilience.

The Egyptian institutional context provides additional insight into this finding. During the study period, environmental considerations became increasingly embedded within banking regulation and sustainable-finance initiatives promoted by the Central Bank of Egypt. Banks progressively expanded green financing activities, incorporated environmental risk assessment into lending policies, and aligned their sustainability strategies with national development priorities. These institutional developments are likely to have strengthened the

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financial relevance of environmental practices, allowing banks to improve risk management while adapting to evolving regulatory expectations.

From a theoretical perspective, the result reinforces stakeholder theory by demonstrating that responding to the environmental expectations of regulators, investors, customers, and society can generate measurable financial benefits. Environmental initiatives therefore appear to create value not only through enhanced legitimacy but also by improving the quality of strategic decision-making and reducing long-term exposure to emerging risks.

The prominence of the environmental dimension also helps explain why the aggregate ESG index remains positively associated with financial stability. Rather than contributing equally, the individual ESG pillars appear to influence bank resilience through different channels and with varying degrees of intensity. Within the present sample, environmental performance constitutes the dominant mechanism through which sustainability translates into greater financial stability, whereas the remaining dimensions exhibit more heterogeneous effects that warrant separate consideration.

5.3. The Social Dimension

Unlike the environmental and governance dimensions, the social pillar does not exhibit a statistically significant independent effect on bank financial stability. While the estimated coefficient remains positive, the absence of statistical significance suggests that social initiatives may influence financial stability through indirect or longer-term mechanisms rather than through an immediate and observable effect on bank resilience.

One possible explanation relates to the nature of social investments within the banking industry. Activities such as employee development, financial inclusion, community engagement, customer well-being, and corporate social responsibility are primarily intended to strengthen human capital, institutional reputation, and stakeholder relationships. Although these initiatives create long-term organisational value, their financial benefits typically accumulate gradually and are less likely to be reflected in short- to medium-term measures of financial stability. Consequently, the contribution of social performance may operate through intermediate channels, including enhanced customer loyalty, stronger reputational capital, improved service quality, and greater stakeholder trust, rather than exerting a direct influence on bank stability.

The finding is broadly consistent with Sercemeli and (Canli & Sercemeli, 2026), who report that social performance may improve profitability without necessarily translating into greater financial stability. Similarly, (Mahboub & Ghanem, 2025); (Chua & Byun, 2025) argue that social initiatives often require substantial investment in the short run, while their economic benefits materialise only over a longer horizon. This temporal mismatch may weaken the direct statistical association between social performance and financial stability within relatively limited observation periods.

By contrast, the result differs from (Pyka, Karkowska, & Nocoń, 2025), who identify the social dimension as the strongest contributor to financial stability. Such inconsistencies are not uncommon in the ESG literature and likely reflect differences in institutional environments, sustainability maturity, regulatory frameworks, measurement approaches, and sample composition. The heterogeneous nature of social indicators also makes them

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particularly sensitive to contextual factors, contributing to the mixed evidence documented across previous studies.

The Egyptian institutional context offers an additional explanation. During the study period, many of the social initiatives undertaken by Egyptian banks were closely aligned with national development priorities, including financial inclusion, community development, entrepreneurship support, and social responsibility programmes. While these initiatives generate substantial societal value, their financial contribution is more likely to emerge over an extended period and may depend on complementary institutional and economic conditions before becoming fully reflected in financial stability indicators.

Accordingly, the absence of statistical significance should not be interpreted as evidence that the social dimension lacks economic importance. Rather, it suggests that its contribution to bank resilience is more gradual, indirect, and context-dependent than that of the environmental and governance dimensions. This distinction reinforces the broader conclusion that the three ESG pillars operate through different transmission mechanisms and should therefore be evaluated separately rather than assumed to exert uniform effects on financial stability.

5.4. The Governance Dimension

The empirical findings indicate that the governance dimension contributes positively to bank financial stability, although its economic influence is more modest than that of the environmental pillar. This result suggests that effective governance remains a fundamental component of banking resilience by strengthening institutional oversight, improving decision-making processes, and enhancing the overall quality of risk management. While governance alone may not generate the largest incremental gains in financial stability, it provides the institutional foundation upon which sustainable banking practices can operate effectively.

Several mechanisms may account for this relationship. Strong governance structures improve internal controls, reinforce board oversight, enhance disclosure quality, and reduce agency-related conflicts, thereby limiting operational and managerial risks. These governance attributes support more disciplined strategic decisions and more effective monitoring of risk exposures, ultimately contributing to greater financial resilience. In banking, where confidence and prudent governance are essential to institutional soundness, these mechanisms are particularly important for maintaining long-term stability.

The present finding is consistent with the evidence reported by (Palmieri, Polato, & Floreani, 2025); (Mahboub & Ghanem, 2025); (Sassi & Lassoued, 2026), who conclude that governance quality plays a central role in strengthening risk management and improving bank stability. Evidence from the Egyptian financial sector also supports this interpretation. (Fouad, 2025) reports that board independence, transparency, and effective risk management contribute positively to financial sustainability, whereas CEO duality adversely affects institutional performance. Collectively, these findings reinforce the view that sound governance mechanisms constitute a fundamental pillar of banking resilience within the Egyptian institutional environment. They also accord with Agency Theory, which argues that effective governance mechanisms mitigate conflicts of interest between managers and

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shareholders, improve managerial accountability, and promote decisions that enhance long-term organisational performance.

The comparatively smaller economic contribution of the governance dimension, however, deserves particular attention. A plausible explanation is that governance standards have become increasingly institutionalised within the Egyptian banking sector through successive regulatory reforms and supervisory requirements issued by the Central Bank of Egypt. As compliance with core governance principles has become more widespread, differences in governance quality across banks have narrowed. Consequently, although governance remains statistically relevant, its relatively limited cross-bank variation reduces its ability to explain differences in financial stability compared with the environmental dimension, where greater heterogeneity in practices still exists.

This interpretation highlights an important distinction between the environmental and governance pillars. Environmental initiatives appear to represent a source of competitive differentiation because banks continue to vary considerably in the scope and maturity of their environmental practices. Governance, by contrast, increasingly functions as a sector-wide institutional prerequisite rather than a distinguishing strategic capability. Its principal contribution therefore lies in providing the governance infrastructure that supports effective risk management and reinforces financial resilience, even if its marginal economic impact is smaller than that of environmental performance.

Taken together, the governance results reinforce the broader conclusion that the ESG dimensions contribute to financial stability through distinct yet complementary channels. While environmental performance explains a larger share of the observed variation in bank resilience, governance remains indispensable in sustaining the institutional conditions under which those benefits can be realised.

5.5. Discussion of the Control Variables

The control variables display a remarkably stable pattern across all model specifications, confirming that the estimated effects of sustainability are not driven by omitted institutional or macroeconomic factors. The consistent significance of bank size and the exchange rate indicates that the relationship between ESG performance and financial stability remains robust after accounting for differences in bank characteristics and the broader economic environment.

Bank size is found to be negatively associated with financial stability, suggesting that larger institutions are not necessarily more resilient. Although larger banks may benefit from economies of scale, broader funding sources, and greater diversification, these advantages can be offset by increased organisational complexity, higher risk exposure, and more demanding portfolio management. As banking operations expand, monitoring costs, coordination challenges, and risk concentration may also increase, potentially reducing the stabilising benefits traditionally associated with scale.

This interpretation is broadly consistent with (Almulla, Albaity, & Al-Tamimi, 2025) and Chouaibi and Ali Ben (2026), who argue that the effect of bank size depends largely on institutional settings and banking-sector characteristics rather than on size alone. The finding, however, contrasts with studies such as (Pyka, Karkowska, & Nocoń, 2025), (Choi, Ryu, &

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You, 2024); (Sassi & Lassoued, 2026), which report a positive contribution of larger bank size to financial stability through diversification and stronger risk-management capacity. These contrasting results suggest that the stability implications of bank size remain context-specific and cannot be generalised across banking systems.

The exchange rate also exhibits a positive and highly significant association with financial stability throughout the sample period. This relationship should not be interpreted as implying that exchange-rate volatility is inherently beneficial for banking stability. Rather, it appears to reflect the institutional and regulatory adjustments that accompanied major macroeconomic changes in Egypt between 2015 and 2024. During this period, banks strengthened their capital positions, enhanced risk-management practices, and adapted their balance-sheet management to operate under a more volatile economic environment. Consequently, the positive coefficient is more likely to capture the sector's improved capacity to absorb external shocks than the direct effect of exchange-rate movements themselves.

Overall, the control variables reinforce the validity of the empirical specification adopted in this study. Their stable behaviour across alternative estimators confirms that the estimated sustainability effects remain economically and statistically meaningful after controlling for key bank-specific and macroeconomic influences, thereby strengthening confidence in the robustness of the reported findings.

6. Conclusion and Implications

6.1. Conclusion

This study examined the relationship between sustainability practices and financial stability in the Egyptian banking sector by analysing both the aggregate ESG index and its individual environmental, social, and governance dimensions. Using panel data for Egyptian banks over the period 2015–2024 and employing multiple panel-data estimators together with a comprehensive set of diagnostic and robustness tests, the study provides consistent evidence that sustainability constitutes an economically meaningful determinant of bank financial stability.

The empirical findings demonstrate that sustainability should not be viewed as a homogeneous construct. Although the aggregate ESG index is positively associated with financial stability, the three underlying dimensions contribute through different channels and with varying degrees of influence. The environmental dimension emerges as the strongest driver of financial stability, highlighting the growing importance of environmental risk management within modern banking. Governance also exerts a positive influence by strengthening institutional oversight and risk-control mechanisms, although its economic contribution is comparatively smaller. In contrast, the social dimension does not exhibit a statistically significant direct effect, suggesting that its contribution to financial resilience is more likely to materialise gradually through indirect organisational and stakeholder-related mechanisms.

Beyond the individual dimensions, the study demonstrates that the estimated sustainability effects remain stable after controlling for bank-specific characteristics and macroeconomic conditions. The consistency of the findings across alternative model specifications and the CRE–Mundlak robustness analysis further strengthens confidence that the documented relationships are not sensitive to model selection but instead reflect a persistent empirical pattern within the Egyptian banking sector.

Taken together, these findings indicate that the contribution of sustainability to financial stability depends not only on the extent of ESG engagement but also on the specific sustainability dimension being considered and the institutional environment in which banks operate. Consequently, treating ESG as a multidimensional framework rather than a single composite indicator provides a more nuanced understanding of how sustainability influences banking resilience. This perspective offers a stronger analytical basis for future empirical research and supports the growing recognition of sustainability as an integral component of modern banking strategy rather than merely a regulatory or reporting requirement.

6.2. Theoretical Implications

The findings of this study offer several contributions to the literature on sustainable banking and financial stability.

First, the results provide further evidence that treating ESG as a single composite indicator may obscure important differences across its underlying dimensions. While the aggregate ESG index is positively associated with financial stability, the environmental, social, and governance pillars differ substantially in both their statistical significance and economic relevance. This finding supports the growing view that sustainability is inherently multidimensional and that examining its individual components provides a more informative explanation of bank resilience than relying solely on aggregate ESG measures.

Second, the study extends the emerging-market literature by providing new empirical evidence from the Egyptian banking sector, a context that remains underrepresented in international research despite its increasing importance within sustainable-finance initiatives. By demonstrating that the relationship between sustainability and financial stability remains robust within an emerging institutional environment, the study contributes to the broader discussion regarding the external validity of ESG-related evidence beyond developed financial systems.

Third, the findings contribute to stakeholder theory by demonstrating that the financial consequences of sustainability are not uniform across stakeholder-oriented activities. The stronger influence of the environmental dimension, together with the more gradual contribution of the social pillar and the institutional role of governance, suggests that different sustainability dimensions strengthen bank resilience through distinct transmission mechanisms. This perspective refines the theoretical understanding of how sustainability creates value within financial institutions and highlights the importance of considering the heterogeneous nature of ESG performance.

Finally, the study offers a methodological contribution by demonstrating the value of estimating separate empirical models for the aggregate ESG index and for each individual sustainability dimension. This modelling strategy not only avoids the multicollinearity that may arise when composite and component indicators are introduced simultaneously but also enables a clearer identification of the independent contribution of each sustainability pillar. The consistency of the findings across alternative model specifications and the CRE–Mundlak

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robustness analysis further supports the reliability of this analytical framework and provides a useful methodological reference for future research examining sustainability and financial stability.

6.3. Practical and Policy Implications

The findings of this study have important implications for banking institutions, financial regulators, and policymakers seeking to strengthen the resilience of the banking sector through sustainability-oriented strategies.

For banks, the results suggest that sustainability should be regarded as a strategic component of risk management rather than merely a compliance or reporting obligation. The positive association between ESG performance and financial stability indicates that integrating sustainability considerations into core banking activities can contribute to stronger institutional resilience. In particular, the prominent role of the environmental dimension highlights the value of incorporating environmental risk assessment into lending policies, investment decisions, and enterprise risk-management frameworks. Banks may therefore benefit from allocating greater strategic attention to environmental initiatives that simultaneously support sustainable finance objectives and long-term financial stability.

The findings also indicate that governance should remain a strategic priority despite its comparatively smaller economic contribution. Effective governance structures continue to provide the institutional framework necessary for sound decision-making, internal oversight, transparency, and prudent risk management. Consequently, banks should view governance not simply as a regulatory requirement but as an essential capability that underpins sustainable organisational performance.

Although the social dimension does not exhibit a statistically significant direct effect on financial stability, this should not diminish its strategic importance. Social initiatives remain fundamental to strengthening stakeholder relationships, developing human capital, promoting financial inclusion, and enhancing institutional reputation. Their contribution is more likely to emerge over longer time horizons and through indirect channels that extend beyond the financial indicators considered in the present study.

For financial regulators and policymakers, the results support continued efforts to strengthen sustainable-finance frameworks and encourage the integration of ESG considerations into supervisory and risk-management practices. The evidence suggests that sustainability can reinforce banking-sector resilience when supported by an appropriate institutional and regulatory environment. Policies that promote consistent ESG disclosure, environmental risk integration, and sound governance standards may therefore contribute not only to sustainability objectives but also to financial-system stability.

More broadly, the study underscores that effective sustainability strategies should recognise the heterogeneous nature of ESG. Rather than treating environmental, social, and governance practices as equally influential, banks and regulators should adopt a differentiated approach that reflects the distinct contribution of each dimension. Such an approach is likely to improve the allocation of resources, enhance the effectiveness of sustainability initiatives, and strengthen the long-term resilience of the banking sector.

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