Winter 2-28-2024

Is ESG a Determinant of Banks' resilience and Growth Everywhere? A Response from an AI-Aided Approach

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Is ESG a determinant of banks' resilience and growth everywhere? A response from an AI-aided approach

A Thesis Submitted by

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Under the supervision of Dr. Mohamed Bouaddi

to the

Master of Science in Finance

Graduate Program

November 2023

In partial fulfillment of the requirements for the degree of

Master of Science

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Abstract

There are many calls for banks to expand their contribution to the transition towards a sustainable world by sponsoring initiatives that promote the United National Sustainable Development Goals. This role is more materialized in developing countries as banks are the key source of funding; thus, they have the power of money to mutate the DNA of businesses to operate responsibly with respect to the surrounding environment and society. Various studies consider the reflection of adopting sustainable approaches by banks, though focusing on developed countries who took the initiative to lead this change. As the banks in developing countries try to catch this up, there is a question about how this endeavor reflects on their return and risk profiles. This study empirically shows that unlike banks in Europe, North America, and Asia, banks in other less-developed areas may exhibit lower returns as they expand their focus on the transition to sustainability rather than asset growth. On the other hand, the study also reveals for those banks in less-developed contexts, there is no significant relationship between banks' sustainable performance and their resilience to distress. These results help to portray an inclusive view of the sustainability-focused strategies in various frameworks where high-income nations are expected to expand their support for poorer countries in order to alleviate their cost of transition especially as the climate change and resources depletion's responsibility is not evenly shared. Also, the study helps policy makers to consider the importance of the prudential supervisory framework to promote sustainability though in relevance to the country's economic and regulatory maturity. From another perspective, the results are useful for banks drawing their strategies to consider the reflection of their engagement in the environmental and social preservation practices within various economic contexts.

1. Introduction

> *"Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs"* (United Nations Brundtland Commission, 1987.)

The United Nations (UN) promotes sustainability as a responsible approach to avoid the degradation of the environment and society because of economic maximization endeavors. Thus, the sustainable approach requires while considering the economic aspect to also consider the environmental, social, and governance (ESG) aspects. Although it is similar to the strategies of corporate social responsibility (CSR,) which also considers the reflection of the corporations' practices on its surroundings (European Commission, 2011,) sustainable strategies aim to embed the responsibility to ESG in the daily operation as well as long term plans and targets. Various acts, mandates, and initiatives are developed to promote objective-oriented frameworks for different business activities to ensure their alignment with the Sustainable Development Goals (SDGs) that are defined by the UN. UN Environment Program – Finance Initiative (UNEP FI,) which is a cooperation between the UN Environment Program and various financial institutions, develops and updates a framework for sustainable finance that is currently underwritten by more than 450 banks with aggregate assets of more than 100 trillion US Dollar (United Nations Environment Program, n.d..) Further, other guidelines are also common in the finance and banking domain like Equator Principles (EP,) Principles of Responsible Banking (PRB,) Principles of Responsible Investment (PRI,) Taskforce on Climate Finance Disclosures (TCFD,) and Green Bond Principles which complement the various aspects of financial intermediation including sustainable operations, products offerings, and risks.

The sustainable finance approach comprises opportunities for the financial institutions (FIs) to expand their business as well as mitigants for risks that may arise from irresponsible behavior amid the threat of climate change. On one hand, achieving the SDGs requires annual funding of $6 trillion by 2030 of which around 50% to be channeled to the developing countries, out of which 80% is expected from private entities. Such budget is expected to increase by 56% because of COVID-19 and Russian-Ukrainian conflict according to the Organization of Economic Co-operation and Development (2022.) Hence, financial institutions that are equipped with sustainable finance strategies and awareness unlock potential roles in intermediating such funds which maximizes their business volume, profitability, and cash flows. For example, the volume of bonds issued for sustainable-related purposes has grown exponentially over the past 5 years to exceed 1 trillion US dollar and expected to surpass 5 trillion on cumulative basis by 2025 (Climate Bonds Initiative, 2022.) On the other hand, financial institutions are also exposed to the risks of

climate change which may affect the value of investment assets or erode its economic feasibility because of the change in climate conditions, natural disasters, or the market preferences towards responsible firms. Loss in financial assets because of environmental and social degradation is expected to arrive at $4.3 trillion while the downside scenario, which assumes strong adverse climate conditions with no response from business communities, is ten times the base case (Gradner, 2015.) Accordingly, embedding sustainability in the strategies of financial institutions qualifies them to deal with their prospect opportunities and risks.

For banks, the risk severity is critical for the whole financial system as they play a vital role in the economy with heavy capital consumption, they are the most common choice for savers and business lending, and they play a pivotal role in various economic functionalities such as the exchange and routing of money as well as the induction of the monetary policy; thus, governments intervene through regulations, and sometimes by funding, to maintain the order of the banking system (Wu & Chen, 2013.) Accordingly, and given the materiality of the risks imposed by climate change, Basel Committee on Banking Supervision (BCBS), in its report "Climate-related risk drivers and their transmission channels", acknowledges the implication of climate change on core risks: credit, market, liquidity, operational, and reputational; however, Basel Committee is yet to determine whether this implication requires and additional capital buffer (BIS, 2021.) Further, BCBS is blamed for the lateness of not clearly defining the best practice in addressing ESG risks and the requirement to manage it on the systemic level despite the detrimental impact of ignoring this aspect (Alexander, 2014.) However, the European Central Bank (ECB) took the initiative to run a climate change scenario on 41 large European banks to measure the sensitivity of their assets to climate risk. The result that stress scenario reveals an expected loss of €70 billion along with the need to expand building the capacity of handling climate risk especially in view that the majority of the inspected banks' assets are invested with counterparties that are extensive in greenhouse gas (GHG) emissions (European Central Bank, 2022.) Such initiative from the ECB comes in light of the European banks' leadership in understanding, recognizing, and responding to the ESG factors significance (Ho et al., 2012.) Accordingly, ESG risks are material and recognized by international bodies being an emerging factor that need to be managed to protect the quality of the banks' assets which is critical for the economy.

In view of these conditions that imply opportunities, risks, and regulations, banks strive to adopt the proper strategy that helps them maximize their benefit while enhancing their resilience. This study provides a comparative analysis of the sustainability-focused strategies on banks risk and return in various areas of the world. The study starts with a review of the existing literature in Section 2 then the hypothesis of this research is developed in Section 3. Section 4 explains the methodology applied to answer the research questions with results summarized in Section 5, and finally conclusion and recommendations are provided in Section 6.

2. Literature Review

The development of ESG scores in the early 2000's by renowned dataset providers like Thompson Reuters and Bloomberg contribute to the research on the impact and causes of firms' ESG activity on their financial and non-financial factors. Banks' financial performance is no exception as it is addressed by various studies concerning the impact of a bank's ESG and CSR activities on their capitalization, cost of fund, liquidity, and quality of assets. Most of these studies find a significant impact especially with respect to the environmental and governance aspects albeit with diverse findings concerning the impact's direction and linearity.

Banks' ESG profile is a significant determinant of their value generation, profitability, and accordingly, their capitalization. Buallay (2019) examines the impact of European banks' ESG and CSR scores on each's Return on Equity (ROE), Return on Asset (ROA), and Tobin's Q measure (TQ) over a ten-year period from 2007 to 2016. The study reveals a significant positive correlation between ESG scores and all the dependent performance variables albeit the breakdown of the three factors (environmental, social, and governance) shows contrast in terms of significance where the environmental aspect is the only persistent factor. Contrarily, Buallay (2019) finds a negative impact of CSR on the banks' performance which she explains being a result of CSR nature that is sought mainly for reputational purposes while adding a financial burden on the bank. Contrarily, ESG strategies transform the bank's activities to be more sustainable by considering external factors in business decisions. This explanation supports the argument of Cespa & Cestone (2007) that a firm's executive management tends to over-focus on CSR as a practice to reassure their positions against the fear of replacement, and shareholders may support this approach to

counter negative publicity that the firm is exposed to. Similar to Buallay's study (2019,) Azmi et al. (2021) assess the sustainable finance impact on the returns of banks headquartered in emerging economies where they arrive to the same significant positive impact of ESG on TQ and interest margins as the banks with better sustainable performance enjoy more diversified access to funding including the funding sources that are linked to responsible banking disciplines. Same conclusion is affirmed by Aydoğmuş et al. (2022) who highlight that ESG and value creation relationship is nonlinear as the incremental benefit to firms returns diminishes as ESG performance increases. Additionally, their study substantiates this relationship with another model concluding a positive correlation between banks' ESG score and their net interest margin (NII), which explains the higher value creation of sustainable finance. All these conclusions highlight ESG, unlike ordinary philanthropy, as a business strategy that maximizes and sustains banks' value which refutes the argument that firms are better to segregate between business and economic strategies from one side and responsibility to the surrounding society from the other side (Devinney, 2019.)

From another perspective, banks' sustainable finance approach reflects, also, on their quality of assets and capital adequacy. Liu & Huang (2022) argue a collinear positive relation between a bank's ESG activity and its combined financial performance proxied by CAMELS indicator which is a product of a bank's capital adequacy, asset quality, management, liquidity, and sensitivity. Such a conclusion is based on a study conducted on fifteen Chinese banks over the period 2008-2019 using an autoregressive model where banks' ESG activity reflects on their performance within only one year whereas the inverse relationship, also, holds with a three-year lag. In agreement with this argument, Sholtens & Klooster (2019) find a significant positive relationship between the ESG scores of the European banks and their Z-Score, which measure the adequacy of banks' capital to afford returns erosion (Berger et al., 2017.) This relationship is justified due to the less earnings variability of the banks that demonstrate adequate ESG activity. Therefore, sustainable finance contributes to better predicting a bank's performance by measuring how the bank addresses the environmental, social, and governance factors. As an empirical proof, Citterio & King (2023) compare between models that segregate underperforming banks with and without considering the ESG score where the models that use ESG score are more accurate and demonstrate a higher precision if also integrated with artificial intelligence-based models. The study indicates that Type II error of misclassifying a low-performing bank as good decreases upon

taking the ESG score as one of the explanatory variables, though Type I error increases which implies that considering ESG performance is a prudent approach to assess the stability of banks as it helps understand its financial standing; hence, ESG is a determinant of a bank's resilience.

Further, the implication of ESG on a bank's performance is magnified during the distress conditions where the sustainable approach followed by banks enhances their resilience and maintains the market trust in their potential. Chiaramonte et al. (2022) conducts research on European banks for the period from 2005 to 2017 measuring their Distance to Default (DTD as a dependent factor that is explained by ESG Score using Merton's process (1974) in addition to integrating Crisis Time as a dummy variable to differentiate the impact during the span from 2008 to 2012 that witnessed the Global Financial Crisis and had a financial reflection on European banks (Andrieș et al., 2016.) The study of Chiaramonte et al. (2022) reveals an insignificant correlation between ESG score and DTD in the normal condition, the relationship turns to be significant with positive direction during the Crisis Time. This relationship holds in both the combined approach of ESG score or its breakdown into Environmental, Social, and Governance factors which implies better resilience of banks that have larger engagement in sustainable finance strategies. Such conclusion agrees with the finding of Albertini (2013) who performed a meta-analysis over 52 studies developed in the period from 1975 until 2011 concluding a significant positive relationship between a firm's environmental consideration and its financial well-standing. This, also, aligns with the capital market perception that ESG-active firms are less vulnerable to crises where various studies reveal that the Chinese and American firms with high ESG scores performed better, in terms of market capitalization, during the COVID lockdowns in 2020 (Albuquerque et al., 2020; Bouslah et al., 2018; Broadstock et al., 2021; Kharlanov et al., 2022,) which affirms the robustness of Chiaramonte et al. (2022) results over various regions and circumstances. All these contributions substantiate the argument of ESG effectiveness in ameliorating the adverse impact of external crises on the financial performance of banks while mitigating its value from market disruptions.

Given the significant impact of ESG on the financial performance of banks and firms in general, the credit rating agencies consider it in their assessment where Kiesel & Lücke (2019) highlight the significance of ESG in the reasoning of rating downgrades performed by rating

agencies where they have deployed a statistical Latent Dirichlet Allocation (LDA) process (Blei et al., 2003) to assess the reasoning of the rating reports issued for 829 firms in the United States and Europe over the period from 2004 to 2015. The study reveals that the ESG aspect contributes to the rationale of rating agency when reviewing the creditworthiness of a firm. The materiality of such contribution increases for downgrades and Watch List categorization with less impact on credit ratings upgrades. The same conclusion is obtained by other studies by Chodnicka-Jaworska (2021) and Zanin (2022) who use econometric logit and probit regression models to measure the significance of ESG score to differentiate between investment and non-investment grade rated firms, albeit these studies focus on nonfinancial firms. The results reveal that investment grade firms exhibit a significantly more engagement in the ESG activity (Chodnicka-Jaworska, 2021; Zanin, 2022.) Further, they elaborate a heterogeneous case where the impact of ESG score is magnified for firms operating in activities that are more exposed to environmental factors such as utility and energy-intensive activities while, on the other hand, the governance factor is more prominent determinant for the other firms. Therefore, and as the credit ratings contribute to drawing the investors' trust in firms (Geyikci, 2023,) adopting a sustainable finance approach stimulates the recognition of the firms' stability as endorsed by the credit rating agencies. However, the reflection of this recognition is yet to be reflected on the bank's cost of fund, especially in emerging markets, as they rely mainly on depositors who are usually inclined towards the banks with the highest credit interest and better customer service rather than responsible ones (Azmi et al., 2021.) Though, such interest of rating agencies and investor's trust highlights the importance of ESG factor when comprehensively assessing a firm's profile.

Broadly, as ESG activity improves banks' profit steadiness, capitalization, and financial stability, this also extends to the macro level where the low vulnerability of large banks enhances the capability of the whole financial sector to afford exogenous shocks which accordingly helps to support the recoverability of the economy. Sholtens & Klooster (2019,) in their research "Sustainability and bank risk", address the impact of ESG scores of banks on their insolvency and that banks with higher ESG scores help to reduce the systemic risk using "SRISK" as a performance variable, which provides a forecast of the mean capital erosion in case of crises. The study was conducted on European banks during 2002-2016 time period and claims that banks with low ESG profiles stimulate systemic degradation. The same conclusion is arrived by Aevoae et al.

(2022) who expand on Sholtens & Kolooster (2019) by measuring the impact on the sensitivity of the financial sector market capitalization during turmoil which also supports the findings of Chiaramonte (2022) regarding the resilience of banks with higher ESG profile during downturns. This highlights the importance of the central banks' involvement as regulators to ensure that banks adopt an adequate sustainable approach in their business to contribute to the financial system's agility (Carney 2015.)

The role of responsible banking practices to enhance the strength of the bank and the economy underscores the need to stand on the drivers of those practices. Gangi et al. (2019) review the factors that explain what drives an ESG score of a financial institution to be higher than its market average using the indicators of 142 banks from 35 various economies over 2011-2016. In this study, the authors focus on various governance attributes as explanatory variables while using other control variables that include profit efficiency, asset size, market share, loans-orientation, and the size of the economy where each bank operates. The constructed model supports the argument that governance practices drive ESG leadership while also revealing a higher significance of the control variables where the least standard error is associated with the bank's size factor then comes the profit efficiency factor. This aligns with the argument of Liu & Huang (2022) concerning the bilateral relationship between ESG practices and the banks' financial stability. Therefore, sustainability is an integral part of a successful bank strategy that aims to stabilize its profit, strengthen its capital, and contribute to the financial sector resilience.

3. Hypothesis Development

This study extends the research conducted by Sholtens & Klooster (2019) as well as Citterio & King (2023) who find that ESG is a significant determinant of banks' risk proxied by Z-Scores. Further, the study adds to the referred literature by examining this relationship globally instead of focusing on European and North American banks. The need for this comparative study comes as the factors affecting banks in developed markets, especially the European ones, cannot be generalized to other less developed contexts. For example, Europe is considered a leading market in applying proactive ESG frameworks (Ho et al., 2012). The contrast in ESG policies applied by different regulatory frameworks was highlighted by Singhania & Saini (2023) as the

reporting requirements and business restrictions vary among developed and developing countries. Similarly, Azmi et al. (2021) find that ESG engagement in a country depends on the requirements made by the regulatory authorities and in view of the competitiveness conditions of the market. From another perspective, the contribution of different regions to the global greenhouse gas emissions is not proportionate where high-income regions, which are mainly in Europe and North America continents, produce intensive GHG emissions unlike the low-income countries that have a much less contribution (International Energy Agency, 2023.) Thus, the first hypothesis tries to figure out whether the negative ESG-risk relationship that is argued for developed countries holds for other parts of the world or the different contexts provokes the significance of ESG score to explain risk.

H1: The significance of ESG score to explain a bank's risk varies in relation to its regulatory and economic context.

The second hypothesis leverages on the relationship that is concluded from the first one while showing that the predictive power of a model that anticipates bank distress improves as it takes into consideration the ESG factor relevant to its region. This replicates the approach applied by Citterio & King (2023) who deploy various models, including machine learning ones, to emphasize the significance of ESG score as a predictor for banks' distress. Though, this study generalizes the existing literature to include the global aspect. Also, this procedure performs another generalization to the conclusion arrived by Addo et al. (2018) who argue that the several machine learning models improve the measurement of default risk especially if compassed with multiple performance indicators, though this study takes the same approach to the overall enterprise risk level rather than only credit risk.

H2: ESG score helps to better predict bank resilience to distress especially if integrated within a machine learning process.

Altering from risk to return, the third hypothesis examines the impact of responsible banking activity on the growth in banks' profitability. This assessment aims to measure whether ESG activity implies a cost-of-profit growth limitation on banks who are taking the lead on this

front. This extends to the research conducted by Aydoğmuş et al. (2022) and Azmi et al. (2021) who conclude a positive reflection of ESG on a firm value creation whereas this study focuses on the net profit growth in specific rather than value creation in general while examining whether ESG score explains the changes in a bank's profits with a comparative approach among various areas around the globe.

H3: ESG score is a determinant of change in a bank's profit where the link varies across countries.

4. Methodology

4.1. Covered Regions

The obtained data were sub-dividend into 5 clusters based on the geographical location of the country where the bank operates. Some countries were excluded due to the incompleteness of data. However, the remaining countries are found to be representative of their regions as they demonstrate most of the credit granted within each region. Figure 1 shows the countries allocation over the regions of study along with their representation.

Figure 1
Allocation of the countries to geographical regions of study

Europe		
	Austria	Sweden
	Switzerland	Turkey
	Germany	Ireland
	Denmark	Czech Republic
	Spain	Italy
	Finland	Netherlands
	France	Hungary
	United Kingdom	Greece
	Norway	Romania
	Portugal	Georgia
	Russia	
% of the Region's Aggregate GDP		91%
% of the Region's Aggrigate Bank Credit to Private Entities		95%

Latin America		
	Brazil	Peru
% of the Region's Aggregate GDP		40%
% of the Region's Aggrigate Bank Credit to Private Entities		46%

Sub-Saharan Africa		
	South Africa	
% of the Region's Aggregate GDP		25%
% of the Region's Aggrigate Bank Credit to Private Entities		60%

Asia		
	Australia	Philippines
	China	Singapore
	HongKong	Thailand
	Indonesia	Korea
	India	Rep. New Zealand
	Japan	Pakistan
	Malaysia	
% of the Region's Aggregate GDP		91%
% of the Region's Aggrigate Bank Credit to Private Entities		89%

MENA		
	Jordan	Egypt
	Kuwait	Saudi Arabia
	Qatar	United Arab Emirates
	Israel	Oman
	Morocco	
% of the Region's Aggregate GDP		59%
% of the Region's Aggrigate Bank Credit to Private Entities		72%

4.2. Variables of Study

This study focuses on ESG performance as a main variable of research which is proxied by ESG-Score calculated by Refinitiv. The study measures the impact of ESG-Score as an independent variable on the selected various dependent variables to assess the correlation of ESG with banks' risk and return over different regions around the world. The same proxy is used by most of literature to assess the impact of an entity's ESG profile on various indicators. Table 1 summarizes ESG-Score levels for each of the regions of study.

Table 1

Ranges of the ESG-Score for the studied dataset by geographical regions

	Number of Banks	Min ESG Score	Median ESG Score	Max ESG Score	Mean ESG Score	Std Dev	CV
Europe and US	303	4.43	38.51	95.43	43.35	19.48	0.45
Asia	98	5.26	50.85	92.84	51.13	19.51	0.38
Latin America	7	10.69	73	89.09	67.61	21.27	0.31
MENA	45	6.99	40.47	80.4	41.76	18.52	0.44
Sub-Saharan Africa	5	27.06	64.25	84.69	59.47	14.75	0.25
Overall	**458**	**4.43**	**41.46**	**95.43**	**45.44**	**19.89**	**0.44**

Note: *the above breakdown of ESG distribution is meant to provide insights on the ranges of ESG scores for the various regions of study; however, all models are run on an aggregated basis while segregating the impact of each region through a different independent variable.*

On the other side, the impact of ESG performance is examined with respect various dependent variables. First, Z-Score is used as a proxy to assess the reflection of ESG on banks' resilience. This approach extends to the research conducted by Citterio & King (2023) who use the same variable as it reflects the adequacy of the bank's capital to cover profitability variance. Second, this study examines the impact of ESG on profitability using various measures to enhance the robustness of the results. Further, several control variables are added to the model to enhance its representation power. This includes controls on the bank's level and others covering the country's level. Table 2 summarizes the key statistics of each of main and control variables.

Table 2

Variables of Study

Variable	Definition
Z-Score	Z-Score that is introduced by Berger et al. (2017.) Calculated as: $\frac{ROA + Leverage}{\sigma(ROA)}$
ESG	Being ESG combined score published by Refinitiv to demonstrate the maturity level of the subject bank in terms of disclosures and practices in relation to environmental, social, and governance aspects.
NPL	Non-performing loans as a percentage to total loans' portfolio.
CDTA	Customers deposits as a percentage of Total Assets which represents how much of the bank's funds are sourced from accepting customer deposits.
TLTA	Total Loans as a percentage of Total Assets which represents the bank's allocation of assets to credit loans.
NII_AD	Net Interest Income as a percentage of Average Deposits which represents the bank's profitability from its deposits.
LTD	Loan to Deposit Ratio as $\frac{Total\ Loans}{Total\ Customers' Deposits}$.
INF	Inflation rate based on the year-on-year consumer price index (CPI) change.
GDP_GROW	The annual growth in gross domestic product (GDP).
criT	Dummy variable to mark crisis years (2008-2012) in alignment to the study conducted by Chiaramonte et al. (2022) for crisis times. Further, year 2020 was marked reflecting COVID-19 breakthrough effect. The variable is multiplied by an activation γ_{income} that relates this variable only to high and middle-income countries based on the studies arguing the limited induction of global financial crisis on low-income countries (Berg et al., 2011.)
NI_GROW5	The overall change in net income over a 5-year period.
ROA	Return on Assets which is calculated as $\frac{Net\ Income}{Total\ Assets}$. The ratio is averaged for time spans of 5 years.
ROE	Return on Equity which is calculated as $\frac{Net\ Income}{Total\ Shareholders' Equity}$. The ratio is averaged for time spans of 5 years.
NIM	Net Interest Margin which is calculated as $\frac{Net\ Interest\ Income}{Total\ Interest\ Revenues}$. The ratio is averaged for time spans of 5 years.

4.3. Data

The study is based on a comparative global review of banks' performance. For that end, data covering the variables of study were collected from Refinitiv for the banks' financial indicators while the macroeconomic indicators were obtained from the World Bank database. The data cover 458 banks in 47 countries over 13 years from 2009 until 2021. Table 3 depicts the key parameters of the research data for each selected variable.

Table 3

Descriptive Statistics for the Variables of Study

Variable	Number	Min	Median	Max	Mean	Std_Dev	Skewness	Excess Kurtosis
Z-Score	2720	5.10	32.83	89.95	34.85	18.68	0.57	-0.26
ESG	2720	1.49	3.72	4.56	3.71	0.49	-0.71	0.61
NPL	2720	0.00	1.49	62.96	2.56	3.72	6.82	79.98
CDTA	2720	0.14	0.75	0.95	0.70	0.15	-1.17	0.93
TLTA	2720	0.11	0.67	0.96	0.65	0.13	-0.72	0.50
NII_AD	2720	0.92	3.84	59.60	4.24	2.83	7.77	98.43
INF	2720	-4.86	1.95	29.51	2.42	2.48	3.04	18.41
GDP_GROW	2720	-0.12	0.02	0.22	0.02	0.03	-0.46	3.41
NI_GROW5	794	-2.09	0.32	2.57	0.34	0.58	-0.14	2.36
ROA5	794	0.00	0.01	0.03	0.01	0.01	0.75	0.38
ROE5	794	0.02	0.12	0.27	0.12	0.05	0.41	-0.03
NIM5	794	0.30	0.54	0.70	0.54	0.10	-0.29	-0.77

4.4. Applied Models

4.4.1. ESG as an explanatory variable of Z-Score

The study relies on several models to construct the argued thesis. The first model (M1) measures the significance of ESG to explain the level of a bank's resilience. Further, in order to elaborate the heterogeneity among different areas in the world, the model breaks down the coefficients of ESG score in terms of various regions as follows. Though, Europe

and United States are grouped in a single factor as an extension to the research conducted by Citterio & King (2023.) Also, logarithm of ESG score is used to align the magnitude among the other variables which are measured on a relative approach.

Model 1 (M1):

$$ZScore_{i,t} = \beta_1 \gamma_{Europe\&US} \log(ESG_{i,t}) + \beta_2 \gamma_{Asia} \log(ESG_{i,t}) + \beta_3 \gamma_{LatinAmerica} \log(ESG_{i,t}) + \beta_4 \gamma_{MENA} \log(ESG_{i,t}) + \beta_5 \gamma_{SubSaharnAfrica} \log(ESG_{i,t}) + \beta_6 NPL_{i,t} + \beta_7 CDTA_{i,t} + \beta_8 TLTA_{i,t} + \beta_9 NII\_AD_{i,t} + \beta_{10}\, INF_{t,c} + \beta_{11} GDP\_GROW_{t,c} + \beta_{12} \gamma_{income} criT_t + \epsilon_{i,t}$$

Where:

$Data\ is\ panel\ allocated\ over$ "i" $banks\ located\ in$ "c" $countries\ and\ over$ "t" $time.$

$$\gamma_{Region} = \begin{cases} 1 & if\ the\ bank\ is\ located\ in\ the\ Region \\ 0 & otherwise \end{cases}$$

$$\gamma_{income} = \begin{cases} 1 & if\ the\ bank\ is\ located\ in\ a\ high\ or\ middle\ income\ country \\ 0 & otherwise \end{cases}$$

A panel model is selected based on the heteroskedasticity among the performance indicators of the banks with significant evidence from the White Test that reveals a p-value of 2.8e-20. Also, there is no material autocorrelation detected as Durbin-Watson test reveals a minimal deviation for 1.9. From another perspective, random effect approach is used rather than the fixed effect as Hausman test reveals no sufficient evidence to reject the null hypothesis (p-value = 1.0).

4.4.2. ESG as a predictive variable for a bank potential vulnerability

The second model (M2) highlight the predictive power that ESG performance adds for the anticipation of a bank's vulnerability. For that end, banks are flagged "vulnerable" in a particular year if their Z-Score in that year falls within the tenth quantile of the whole

population. Further, a one-year is applied on all predictors to assess their power to foresee the vulnerability ahead. However, this assessment applies only on European, North American, and Asian regions in view of the detected significant relationship between ESG and Z-Score for banks headquartered in these areas.

This review is performed through three models that deploy various procedures. First, M2 model is based on a logistic regression that measure the probability of a bank to be categorized as vulnerable in a certain year based on the bank's attributes in the previous year. M2 starts with measuring the significance and calibrating the coefficients on a training subset that represents 67 percent of the whole dataset then validates the model performance over the remaining 33 percent of the data (out of sample).

M2:

$$P(Vulnerable_{t+1}) = \frac{1}{1+e^{-(\beta_1 \Delta ZScore_t + \beta_2 ESG_t + \beta_3 NPL_t + \beta_4 NII\_AD_t + \beta_5 INF_{c,t} + \beta_6 GDP\_GROW_{c,t} + \beta_8 criT_{c,t} + \beta_8 criT_{c,t+1})}}$$

Where:

$$\Delta \textit{ represents the change of ZScore over a historic} \text{ two-year } \textit{period}$$

The other two predictive models are based on "decision tree" algorithm that learns from the training data subset by assessing the information gain (entropy) that results from dividing the data based on each predictor. Thus, the predictor with the highest entropy is the most to reduce ambiguity by reducing the data impurity which is measured by "gini" (Russel & Norvig, 2016). Accordingly, decision tree deduces the prediction process by repetitive subdivision for the data based on various predictors (v) from 1:n starting with the predictor that demonstrates the highest entropy until reaching certainty about the prediction at gini = 0 from each decision-making branches of the constructed tree.

$$Entropy = \sum_n (v_n) \,.\log_2 \frac{1}{v_n}$$

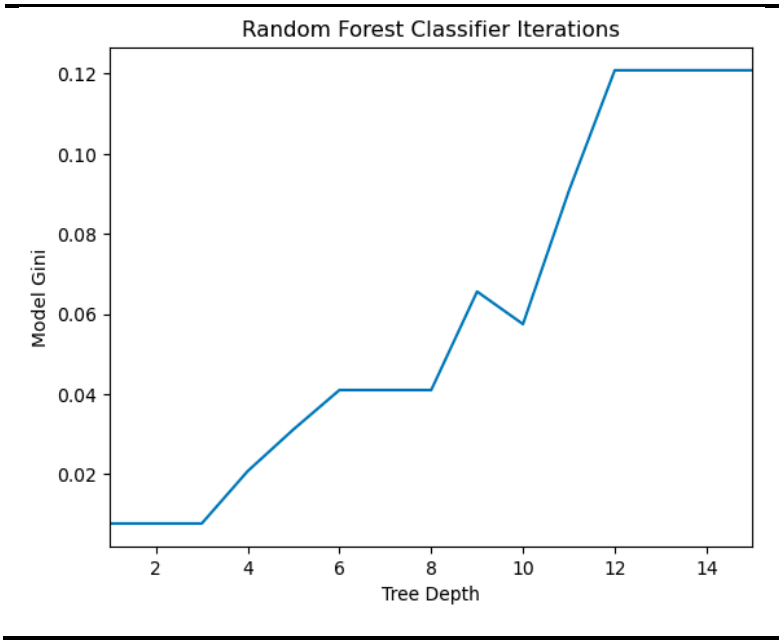
However, decision tree algorithm entails a risk of over-fitting the model parameters based on the training data; thus, random forest process, that was firstly introduced by Ho (1995,)

improves the results generalization by performing the training over a forest of multiple trees rather than only one. Under this approach, the training data is randomly subdivided into various subdivisions based on each a tree is developed with final parameters deduced as an average of whole forest. For that end, the third model (M3) is based on random forest algorithm that train the coefficient parameters based on 10,000 trees.

Further, to enhance the performance of the model to better anticipate vulnerability, the model was tested to detect the tree depth that achieves the best performance in terms of normalized gini coefficient. Graph 1 shows the iterations performed to reach the optimum depth which is found to start at a depth of 12 search levels. Accordingly, all the forest trees are pruned to that optimum depth.

Graph 1

Random Forest Optimization Procedure



The last predictive model (M4) is based on Chen & Guestrin's (2016) development for random forest process by developing the gradient boosting of parameters deduction to be based on the enhancement added from each new tree in the forest.

Each of the three models (M2, M3, and M4) is run with and without the consideration of ESG factor to highlight its incremental enhancement to the model performance.

4.4.3. ESG as an explanatory variable for banks' profitability

Like the assessed ESG-risk relationship, another model is developed to assess whether the ESG score explains the change in a bank's profitability and in which direction. Similarly, ESG factor is segregated for each region to assess the variability of the effect. Hence, "profitability" is proxied by various indicators: return on equity (ROE), return on asset (ROA), net interest margin (NIM), and net income compound annual growth rate.

This review is performed over a time span of 5 years to examine the medium-term reflection of ESG performance and magnify the impact on profitability.

M5:

$$Profitability_{i,t} = \alpha + \beta_1\gamma_{Europe\&US}\log(ESG_{i,t}) + \beta_2\gamma_{Asia}\log(ESG_{i,t}) + \beta_3\gamma_{LatinAmerica}\log(ESG_{i,t}) + \beta_4\gamma_{MENA}\log(ESG_{i,t}) + \beta_5\gamma_{SubSaharnAfrica}\log(ESG_{i,t}) + \beta_6 NPL_{i,t} + \beta_7 LTD_{i,t} + \beta_8 LEV_{i,t} + \beta_9 NII\_AD_{i,t} + \beta_{10} MKT\_SH_{i,t} + \beta_{11}\, INF_{t,c} + \beta_{12} GDP\_GROW_{t,c} + \beta_{13}\gamma_{income} criT_t + \epsilon_{i,t}$$

Where:

$Data\ is\ panel\ allocated\ over\ banks$ "i" $located\ in\ country$ "c" $and\ over\ time$ "t".

$$\gamma_{Region} = \begin{cases} 1 & if\ the\ bank\ is\ located\ in\ the\ Region \\ 0 & otherwise \end{cases}$$

$$\gamma_{income} = \begin{cases} 1 & if\ the\ bank\ is\ located\ in\ a\ high\ or\ middle\ income\ country \\ 0 & otherwise \end{cases}$$

"Total Assets Growth" was excluded from the model given its eigen value of 2.2 with exhibited collinearity of 0.6 inflation and 0.5 with GDP growth; accordingly, it is believed that the ignored variable is already fully explained by the other two.

Like M1, M5 is based on panel data that demonstrate heteroskedasticity among the performance indicators of the banks with significant evidence from the White Test. Also, there is no material autocorrelation detected as Durbin-Watson test reveals a minimal deviation for 1.5. From another perspective, fixed effect approach is used rather than the random effect as Hausman test reveals no sufficient evidence to reject the null hypothesis (p-value = 3.03e-6).

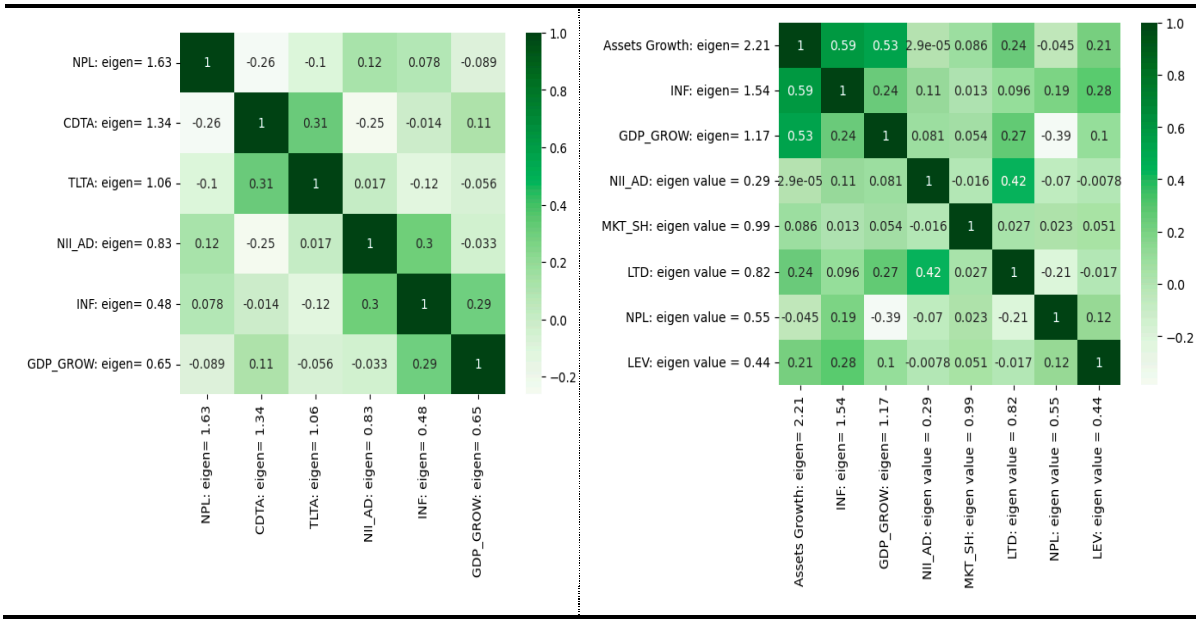
5. Results

5.1. Collinearity Check

Correlation matrix is calculated for the explanatory variables of each regression model to avoid multicollinearity. Figure 2 shows the coefficients of correlation as well as their eigen values within the matrix of independent variables. Based on the results, "Total Assets Growth" is omitted in M5 being well explained by inflation and GDP growth.

Figure 2

Collinearity check for the independent variables in M1 and M2



5.2. Model Result and Performance

5.2.1. ESG on Z-Score

Table 4 summarizes the results of M1 which reveals that ESG is a significant explanatory variable for a bank's resilience in Europe, United States of America, and Asia with positive relationship between both variables. This matches with the results of Citterio & King (2023), Sholtens & Klooster (2019), and Liu & Huang (2022). In contrary, the relationship does not statistically hold for banks located in Latin America, MENA, and Sub-Saharan Africa because of high standard error for each calculated coefficient.

Table 4
M1 Results

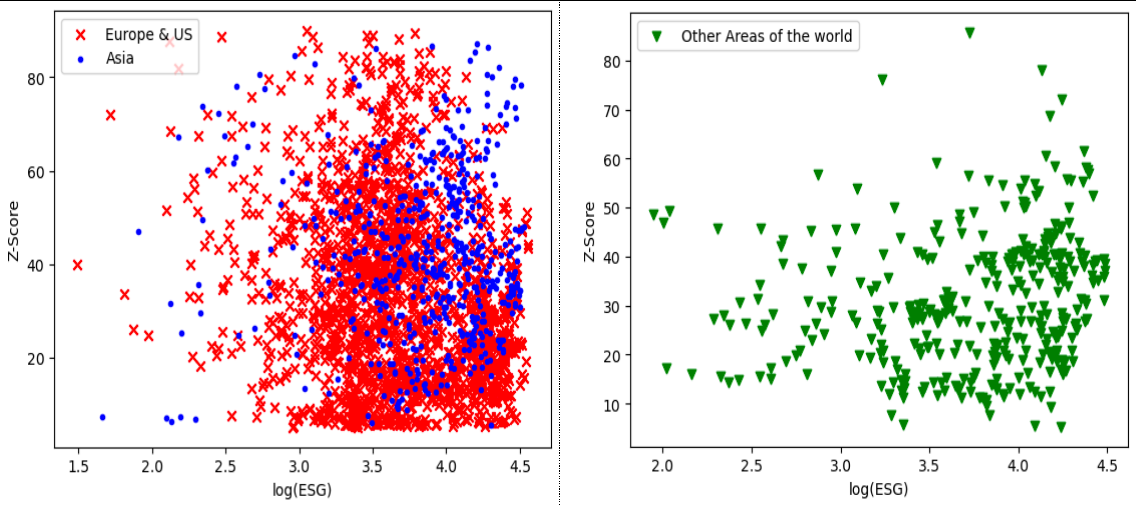
Variables	**Z-Score**
ESG (Europe & US)	1.2137 (0.5984)**
ESG (Asia)	4.3809 (1.1222)***
ESG (Latin America)	0.3467 (0.8355)
ESG (MENA)	-0.2952 (1.0656)
ESG (Sub-Saharan Africa)	1.5649 (1.3605)
NPL	-0.0046 (0.0407)
CDTA	2.6547 (3.2621)
TLTA	10.7284 (2.539)***
NII_AD	0.4812 (0.2027)**
INF	-0.2587 (0.0627)***
GDP_GROW	0.5750 (4.5225)
criT (high- & middle-income countries)	-1.8058 (0.3151)***
F-statistic	39.602 (3.5398)***
R-squared	0.1493
No. of Observation / Degree of Freedom	2720 / 2707

Standard errors are reported inside parentheses besides each coefficient.
**indicates significance using 90 percent confidence interval (p-value < 0.10).*
***indicates significance using 95 percent confidence interval (p-value < 0.05).*
****indicates significance using 99 percent confidence interval (p-value < 0.01).*

These results support the argument that the positive impact of ESG on a bank's risk profile depends on its regional context. The same conclusion is arrived when plotting the relationship for Europe, North America, and Asia where the positive correlation is apparent while for other areas of the world, no significant linear relationship can be detected. Figure 3 shows a comparative scatterplot.

Figure 3

Scatter plot for the ESG/Z-Score relationship for various areas of the world



There is no surprise in such conclusion as the countries located in Europe, North America, and Asia are taking the lead in adjusting their prudential frameworks to be more environmentally and socially responsible. For example, the majority of regulatory bodies who founded the "Network for Greening Financial Systems" (NGFS) are from Europe, Asia, and North America (NGFS, 2023). Given that NGFS has a mission of integrating the environmental risk management within the business of financial institutions, the regulations set in the three mentioned regions converged extensively to require banks to adopt effective ESG risk management strategies.

From another perspective, shareholders' preference adds another call for banks to adopt a sustainable business framework. This is materialized as various non-governmental organization (NGOs) issues publication on firms ESG practices. As an example, Carbon Disclosure Project (CDP) is a leading not-for-profit entity that provides insights and

analysis on firms' carbon activity. During 2022, around 19 thousand firms disclosed their ESG data to CDP including more than 740 financial institutions with total assets exceeding 130 trillion US Dollar most of which are located in Europe, North America, and Asia which are the main continents where CDP is based. The data of CDP is used by many large investors with spending power of $6.4 trillion US Dollars (CDP, 2023.) Accordingly, the pull power of investors adds to the push power of regulators for banks and financial intermediaries towards in those regions to adopt a more ESG responsible approach.

In such context that positions ESG as a requirement by various stakeholders in the three continents, it becomes a target for banks to align their policies and disclosures to reflect their commitment to ESG which explains the persistent correlation between ESG and risk profiles in such regions where banks with low ESG profiles tends to demonstrate less resilience.

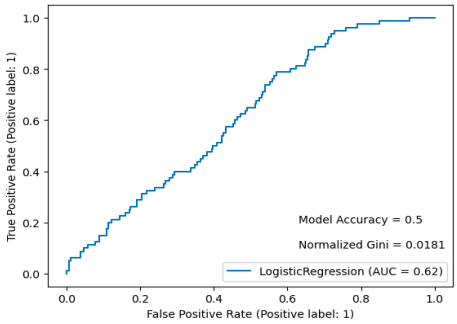
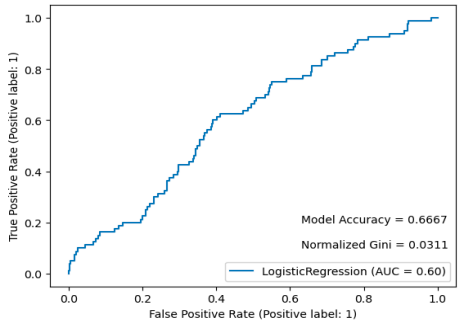
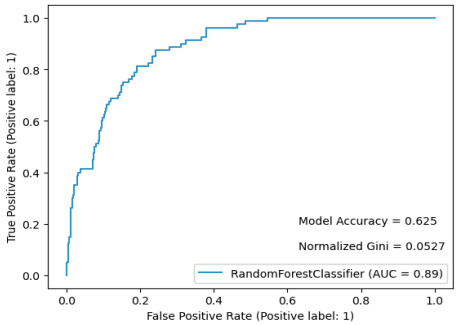
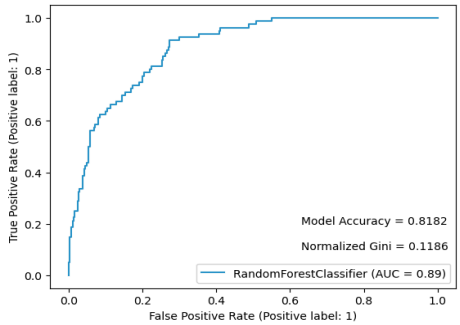
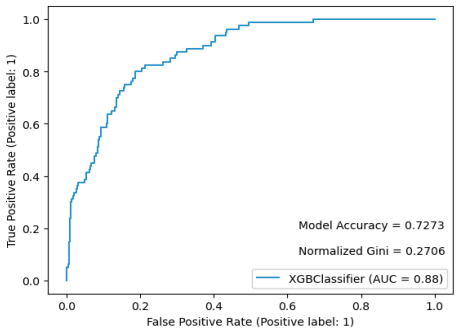
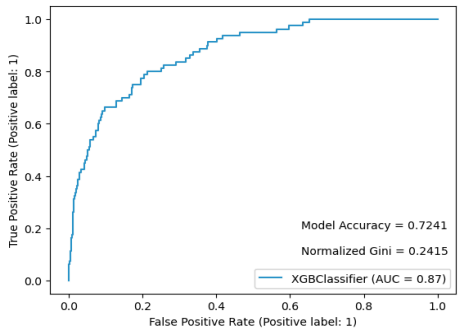
In contrary, the relationship does not persist for banks located in other emerging regions in Africa and Latin America. This matches with the argument of Miralles-Quiros et al. (2019) that the regulatory frameworks vary in terms of responsible business integration. Accordingly, and given that regulators in such regions demonstrate a shorter track record and advancement in this respect, banks ESG activity are derived from internal initiative or sometimes down streamed from international parent group. Thus, ESG represent no significant implication on the banks' risk profile in MENA, Sub-Saharan Africa, and Latin America where ESG approach tends to be non-compulsory approach with no significant appreciation from the investors' sentiment.

5.2.2. ESG as a predictor of banks' vulnerability

Figure 4 summarizes the performance of the applied predictive models where the general observation that the power of the model increases by adding the ESG score. Also, the results reveal the better performance of Random Forest and Xgboost models over the Logistic Regression as the first two avoid overfitting noise in the training data.

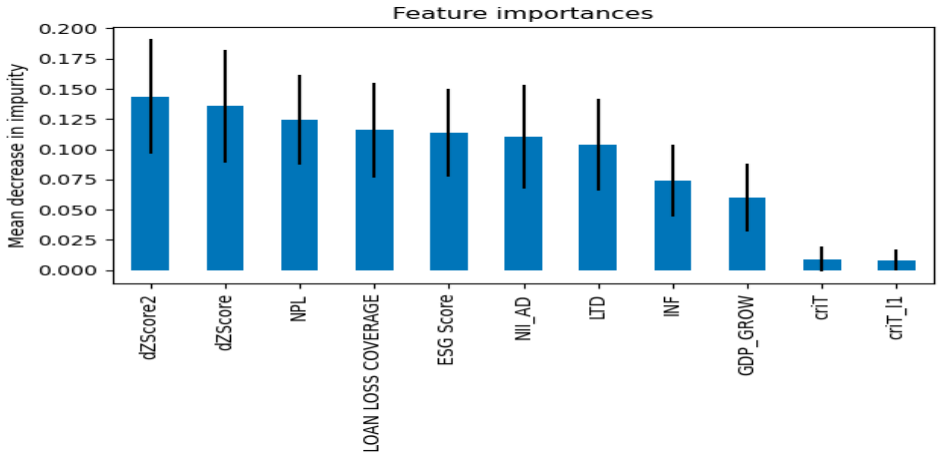
Figure 4

Models' performance on the testing dataset for banks located in Europe, North America, and Asia

	Without ESG Factor	**With ESG Factor**
Logistic Regression Model (M2)		
Random Forest Model (M3)		
Xgboost Model (M4)		

From another perspective, by looking at the details of the trained Random Forest and Xgboost models, the deduced features' importance reveals that ESG score is the fourth most important factor to eliminate ambiguity. This is because ESG score reduces data impurity by 0.11. Worth mentioning that the first three factors are the historical change in Z-Score, NPL percentage, and loan loss coverage percentage where the three are directly correlated with the banks' quality of assets and profit adequacy to cover its losses. Though ESG factor comes before other core factors like the profitability over average deposits, loan to deposit ratio, and the macroeconomic indicators.

Figure 5
Models Performance on the Testing Data



These results support the robustness of the first explanatory model (M1) where the variables that were found to be in significant correlation with the banks' resilience are also good predictor to anticipate its potential vulnerability.

5.2.3. ESG and banks profitability

Turning to the other performance aspect (profitability), several models are developed to measure the significance of ESG activity on a banks' returns over 5-year spans using various profitability measures (Net Income Growth, Return on Assets ROA, Return on Equity ROE, and Net Interest Margin NII.) Table 5 depicts the results of the models.

Similar to the first model (M1), the significance of the relationship varies according to the region of the bank operations. However, in contrast to risk indicators, profitability indicators are significantly affected by ESG in regions other than Europe, North America, and Asia. By matching this conclusion to the previous discussions, ESG is found to be with no significant implication on the profitability of banks headquartered in markets that are characterized by its matured ESG regulation and materialized investor. Though, for other markets, ESG is found explaining a negative growth in profitability and sometimes with inefficiency in profit generation. Accordingly, unless being promoted within the prudential and investors' preference context, ESG endeavor is limited to banks' internal discretion which is found to come on the account of the bank's growth and profitability.

Table 5

Model "M5" showing the impact of ESG on various profitability measures

Variables	NI_GROW	ROA	ROE	NIM
ESG (Europe & US)	0.045 (0.064)	-0.0002 (0.0002)	-0.002 (0.0024)	0.003 (0.0068)
ESG (Asia)	0.0275 (0.0385)	-0.0001 (0.0002)	-0.0011 (0.0017)	-0.0045 (0.004)
ESG (MENA)	-0.1588 (0.0864)*	0.0006 (0.0002)**	0.0087 (0.0031)***	-0.0212 (0.0077)***
ESG (Latin America)	-0.0648 (0.0864)	0.0011 (0.0003)***	0.0123 (0.0032)***	0.0135 (0.0111)
ESG (Sub-Saharan Africa)	-0.1833 (0.0539)***	-0.0001 (0.0002)	-0.0003 (0.0029)	-0.0082 (0.003)***
INF	4.2031 (1.5166)***	0.0332 (0.0117)***	0.4177 (0.1111)***	-0.7934 (0.1941)***
GDP	0.8659 (0.9044)	0.0129 (0.0023)***	0.1409 (0.0259)***	0.4566 (0.081)***
NII_AD	0.0151 (0.0191)	0.0 (0.0001)	0.0004 (0.0006)	0.0024 (0.0018)
MKT_SH	-0.0528 (0.0578)	-0.0004 (0.0002)**	-0.0059 (0.0019)***	0.0103 (0.0067)
LTD	0.0861 (0.1455)	0.0007 (0.0005)	0.0075 (0.005)	0.0092 (0.017)
NPL	0.0709 (0.0272)***	-0.0003 (0.0001)***	-0.0036 (0.0007)***	-0.0024 (0.0031)
LEV	-0.4971 (2.4963)	0.0931 (0.0127)***	-0.1676 (0.1046)	0.496 (0.3378)
criT (high- & middle-income countries)	0.3736 (0.2222)*	0.0005 (0.0002)***	0.0044 (0.002)**	0.0316 (0.0142)**
F-statistic (SE)	3.9165 (0.3171)***	34.312 (0.0013)***	21.865 (0.142)***	18.647 (0.0274)***
R-squared	0.0963	0.4134	0.3099	0.3365
No. of Observation / Degree of Freedom	647/633	647/633	647/633	647/633

Standard errors are reported inside parentheses beside each coefficient.

**indicates significance using 90 percent confidence interval (p-value < 0.10).*

***indicates significance using 95 percent confidence interval (p-value < 0.05).*

****indicates significance using 99 percent confidence interval (p-value < 0.01).*

Although these results differ from the study of Azmi et al. (2021) in terms of the relationship direction; however, the later followed another clustering approach by grouping banks in emerging markets while this study group banks based on geographical location to focus on the regional competitiveness of a bank. From another perspective, these results agree with Azmi et al. in terms of the relationship non-linearity and diminishing returns of EGS efforts.

Though, a question arises about the reason firms in flexible ESG regulatory framework may seek to take this initiative. The answer for this question is found to include several reasons. First, the leading countries and supranational organization in developed countries exert effort to propagate the responsible banking and business practices to the emerging and less mature markets. Brussels Effect (Bradford, 2012), which refers to the influence that European Union gains due to its position as a major trading and financing power over other areas of the world. For example, the European Commission launched in October 2023 the "Carbon Border Adjustment Mechanism" (CBAM) which requires accounting for carbon footprint not only within the European Union member countries but extends to the suppliers exporting to Europe. This practice is expected to stimulate all businesses that directly or indirectly deal with counterparts in the European Union to make their carbon footprint controlled. Also, the major trade partners of the European Union, especially in developing countries, need to update their policies in order not to adversely impact their trade balance (Magacho & Godin, 2023.) Another example from finance domain, European Investment Bank (EIB) provided 9.3 billion Euro to non-European markets (EIB, 2021) whereas European Bank for Reconstruction and Development (EBRD) reached in 2021 a cumulative funding of 31.7 billion Euro to markets outside Europe (EBRD, 2021.) Such funding is usually assessed based on several factors that necessarily the ESG performance of the non-European investees. Accordingly, firms outside Europe are highly motivated to demonstrate responsibility towards ESG to maintain their business and financial relationship with the European Union countries.

Another reason for the induction of ESG commitment to less regulated markets is the global ownership. For instance, 97 out the top 100 banks in terms of assets come from

European, North American, and Asian origins (S&P Global, 2023). Thus, and based on the principles for the supervision of banks' foreign establishments (Concordat) that was issued by Basel Committee for Banking Supervision in 1975 and updated in 1983, banks are required to extend the implementation of their prudential requirements to their subsidiaries located in less regulated markets (BIS, 1983). Accordingly, the requirement originally established in Europe, North America, and Asia are implicitly applicable on the subsidiaries of the banking groups headquartered in those three areas. This complements the explanation of the initiative that may be undertaken by banks although not being required by law or shareholders.

Moreover, the regulatory framework of the emerging markets in Africa, Middle East, and Latin America are simultaneously converging towards more commitment towards ESG. As evidence, the number of NGFS members are increasing where most of the new joiners are regulators from emerging and less-developed markets in response to the encouragement, political influence, and opportunities promoted by the leading developed countries and the supranational organizations. To materialize this transition, the International Financial Reporting Standards Foundation (IFRS Foundation) formed the International Sustainability Standards Board (ISSB) to adopt specialized standards for firms to report on sustainability. Based on that, ISSB issued IFRS S1 and IFRS S2 standards in June 2023 as requirement for firms to disclose on their climate and sustainability-related risks (IFRS, 2023.) This evolution is believed to stimulate the convergence in local jurisdictions and to decrease the ESG information asymmetry. However, the impact of that is yet to be empirically studied until more national systems take the decision applying these standards, and until the updated financial reports and ESG scores are made available to re-assess the ESG impact.

Though, based on the empirical results coming from the less ESG-regulated markets for the period of study (until 2021), ESG-responsible strategies come at the expense of profit generation. This justifies the calls made by the emerging markets for the developed countries to share bearing this transition cost. These demands come since developed countries are principally responsible for climate change because of their extensive

industrialization activity that sweeps the savings achieved by their deployment of cutting-edge technological solution to enhance energy efficiency, and despite the applied carbon tax and similar practices. Hence, during the twenty-fifth Conference of Parties (COP25), many countries urged the importance of achieving "climate justice" where rich countries should support incurring the cost anticipated for low-income countries to transform their frameworks to be more sustainable and to adapt to the realized implications and damages to their communities because of the climate change (Wyns, 2023.) The following annual COP rounds extended this approach where COP27 held in 2022 reiterated the need to mobilize more funding for the developing countries while inaugurating a "Fund for Loss and Damage" to help alleviating the negative financial implication of climate change on poorer countries (UNFCCC, n.d.)

6. Conclusion and Recommendations

The results of the performed empirical study match with the previous research that claims a positive reflection of ESG performance on a bank's resilience with no significant opportunity cost if considered for developed countries. However, this study extends the coverage of the research to cover less-developed market where ESG is found to have no significant reflection on risk while it may have a negative reflection on profit generation and efficiency.

Though, the economic and regulatory contexts are rapidly changing where unmatured ESG frameworks evolve to align with the international approaches of responsibility. From a bank risk perspective, the potential global transition in regulatory framework necessitates the need to adopt agile policies, conduct stress testing, and plan capital to consider such accelerating changes. That is why Basel Committee on Banking Supervision (BCBS) issued "Principles for the effective management and supervision of climate-related financial risks" in June 2021 guiding regulators on responding to such changes; however, this is yet to be a compulsory capital requirement especially in developing countries which is another factor to potentially change the results of this study in the near future.

Though, based on this study conclusions which find asymmetry reflection of ESG on banks' performance based on the maturity of its economic and regional context, the study recommends

that the evolution in new requirements is better come comprehensive enough to consider that context. For instance, banks located in developing emerging markets that are still in early stage of adopting ESG frameworks are better to shift gradually. This gradual transition is justified as it is proportionate to the asymmetric contribution of different regions to climate change and also the variability of the markets exposure to it.

As an extension to this study, further research is recommended to consider the representation power that ESG score demonstrates and how to ensure its magnitude among the various countries. This aims to avoid misrepresentation of the score because of variations in the materiality among various firms. Also, it helps to ensure materializing the benefits of ESG efforts to reflect on the national and global levels and to avoid false representation which is found to be in a negative association with the actual sustainable performance (Zhang et al., 2023.) Also, it is recommended to empirically study the reflection of regulatory convergence in developing countries on banks and firms' performance. This helps to conclude the key success factors that would help firms to maintain their current value creation while adequately managing their risk exposure.

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