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ESG Integration and Cost Efficiency Assessment: Evidence from GCC Banking

Abdullah Aldousari*

Aberystwyth University, Aberystwyth, Wales, United Kingdom. *Email: aba76@aber.ac.uk

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ABSTRACT

This research examines the impact of Environmental, Social, and Governance (ESG) factors on cost-efficiency in GCC commercial banks, with a specific focus on how these effects hold. The analysis uses a one-step Stochastic Frontier Analysis (SFA) and panel data Generalized Least Squares (GLS) regression, covering 46 banks across the GCC region for the period of 2018-2022. Results reveal that Environmental and governance factors have a positive and significant impact on bank inefficiency, while social factors have no significant effect. Further analysis reveals that social and governance factors become efficiency-enhancing under strong institutions. ESG initiatives increase costs in the short to medium term when ESG scores are low, unless they are strategically integrated into core operations. Inefficiency also arises with higher NPLs, capital reliance and weaker governance during the COVID-19 crisis. This research offers novel evidence on the conditional and context-dependent impact of ESG practice on bank efficiency in the GCC region, highlighting differences across ESG dimensions during a major exogenous shock.

Keywords: Environmental, Social, and Governance, Stochastic Frontier Analysis, GCC Banking Sector, Cost-efficiency, COVID-19 Crisis
JEL Classifications: G21, G56, C23, D24

1. INTRODUCTION

Over the past decades, there has been a growing recognition that banking systems need to move beyond their commercial focus (Galletta et al., 2023). Excessive emphasis on intermediation activities has often led banks to overlook environmental, social and governance (ESG) factors of public welfare. In response, many banks have started integrating ESG practices[1] into their strategic and risk management framework. ESG integration can enhance stakeholder trust and long-term value; however, it also poses challenges due to the substantial costs associated with compliance and implementations (Algeri et al., 2025). The COVID-19 pandemic further amplified these challenges; it served as a natural experiment, subjecting banks to exceptional financial stress.

Under the stakeholder theory, ESG activities mitigate risk-taking by aligning corporate behavior with the interests of diverse stakeholders, thereby enhancing efficiency (Freeman et al., 2004). In contrast, the trade-off theory suggests that ESG practices may reduce efficiency and profitability if the associated costs divert resources away from productive investments (Barnea and Rubin, 2010). Meanwhile, the resource-based view (RBV) argues that ESG initiatives can generate sustainable competitive advantages by improving reputation, resilience and reduce operational risks (Freeman, 2010). Yet, ESG is still seen as a cost rather than a value-adding in some regions, pointing to a need for policies that align development with sustainability goals (Yuen et al., 2022).

In the Gulf Cooperation Council[2] (GCC), ESG integration has gained policy and institutional attention as countries aim to diversify their economies away from hydrocarbons (Khatatbeh

1 ESG are defined as a set of criteria and standards to assess and control the environmental, social, and governance performance and responsibilities of businesses (Di Tommaso & Thorton, 2020).

2 The member states of the Gulf Cooperation Council are: Saudi Arabia, Bahrain, Qatar, Kuwait, the United Arab Emirates, and Oman.

et al., 2025). Recent regulatory reforms, such as the guidelines of Basel Committee on Banking Supervision (BCBS, 2022), outlines how key ESG risks can be addressed while maintaining effective risk management systems, focusing on how ESG factors can impact credit, market, liquidity, and operational risks. In response to both investor demand and growing regulatory pressures, banks in the region are incorporating ESG risk factors into their risk management frameworks to remain compliant. Despite these developments, the GCC banking sector still face constraints –not due to a lack of capital- but rather how it is prioritized. ESG practices are still considered in its early stage, on average, only 34% of banks disclose sustainability reports in 2022, compared to 0% 10 years ago (Srairi, 2024). For instance, Saudi Arabia demonstrated moderate growth, particularly in environmental initiatives, while other GCC countries –with the exception of the UAE[3]- lag behind in governance and social practices due to weak regulatory frameworks and low sustainability norms (ElAlfy et al., 2025). However, the development in sustainable practice has been noticeable over the past years, aiming to promote ESG initiatives and social responsibility, with regional efforts guided by the National Visions of GCC countries (2030-2035). In the banking context, these attempts are still voluntary, banks have not yet made tangible efforts toward environmental infrastructure; there is a significant gap in environmental innovation, highlighting the need for more specific alignment (Srairi, 2024).

The relationship between ESG and bank efficiency is context- and sectors-specific (Forgione et al., 2020). In the GCC, structural challenges constrain the efficiency gains and the ESG initiatives. The banking sector is consolidated –dominated by a few large banks. ESG initiatives remain fragmented –only large banks have the capabilities to implement complex initiatives (Aldousari and Alsabah, 2025). Additionally, banks rely heavily on capital to absorb inefficiencies, and limited input and output diversification further restrict operational flexibility. Given these complexities, analyzing how ESG practices may facilitate or hinder operational inefficiency is critical. This research employs the Stochastic Frontier Analysis (SFA), Random Effects (RE), and Truncated Regression (TR) to assess the impact of ESG components on cost-inefficiency. Further, incorporates the institutional quality factors (IQF), which further enrich the GCC literature on the ESG and efficiency relationship. The remainder of this article is stated as follow: Section 1 presents the introduction, Section 2 presents the literature review, and 3 presents the methodology, Section 4 and 5 includes the estimation analysis, discussion, robust checks and conclusion.

2. EMPIRICAL LITERATURE AND HYPOTHESIS

In the previous literature, there are abundant studies examining multiple issues of ESG and the financial sector, the research combines related studies which focus on cost-efficiency, ESG adoption, and COVID-19 in relation to our main problem. Alqahtani et al. (2017) observed increased efficiency during the Global Financial Crisis (GFC), their findings indicate that capital reliance is adversely associated with bank lending, and positively with operational efficiency. While Alsharif (2020) identified country-level differences in the GCC, Bahrain and Oman banking sector outperformed those in Saudi Arabia and Kuwait in terms of cost-efficiency, moreover, large size banks are positively associated with efficient operations. Conversely, Al-Gasaymeh (2020) observed that as bank size grows larger, the average cost per unit of output increases due to complexity. In the ESG context, Chang et al. (2021) argue that in Asia developed economies, banks possess high levels of cost-efficiency due to better environmental practices, and notably, the cost of ESG adoption is significantly higher than its benefits in emerging economies. In contrast, Forgione et al. (2020) noticed that greater activities in environmental and social dimensions increases bank inefficiency, while governance indicator is insignificant. Many studies have highlighted that social activities are costly; as it erodes bank profitability and increases operational risk (Di Tommaso and Thorton, 2020; Galletta et al., 2023). Conversely, social pillar is founded positively associated with interest-income and profitability (Wu and Shen, 2013). Larger banks attain higher levels of efficiency due to economies of scale; they are also highly vulnerable to governance and internal management practice (Algeri et al., 2025). Aldousari and Alsabah (2025) and Verma and Kashiramka (2025) offer complementary evidence on the role of ESG in banking efficiency. The former employed both traditional SFA and ESG-integrated models and showed that ESG factors reduce capital reliance, lower idiosyncratic risk, and decrease the costs of fee-income activities. The latter found that stronger ESG performance leads to better cost-efficiency and greater liquidity creation. Furthermore, a U-shaped relationship is found in Europe, where banks with higher social responsibility and governance practice are more cost-efficient, while environmental aspects show no significant effect on efficiency (López-Penabad et al., 2023). Al Abri and Albulushi (2022), and Srairi et al. (2022) both examined the governance performance and efficiency in the GCC. The former found that bank governance is positively associated with inefficiency, once governance indicator is weak, bank resources are misused. While the latter argue that the reduction in accountability enables the managers to act in their own interests rather than those of stakeholders. It is argued that ESG activities may lower banks' profitability during COVID-19 due to the high cost of ESG adoption (Yuen et al., 2022). However, banks with superior ESG performance are less risky, and could outperform the market during a crisis period (Takahashi and Yamada, 2021). Therefore, it is essential to test these dimensions individually and collectively in the context of the GCC banking systems:

H_1: There is a positive impact of overall ESG performance on bank inefficiency

H_2: There is a positive impact of overall environmental performance on bank inefficiency

H_3: There is a positive impact of overall social performance on bank inefficiency

H_4: There is a positive impact of overall governance performance on bank inefficiency.

3 The UAE leads in ESG improvements, particularly in environmental performance, driven by strong institutional frameworks and alignment with global standards (ElAfy et al., 2025).

The literature presents mixed findings on the impact of ESG in banking. Extensive global research has explored ESG as a determinant of bank cost-efficiency across regions – including Asia (Chang et al., 2021), Japan (Takahashi and Yamada, 2021), Europe (López-Penabad et al., 2023; Algeri et al., 2025), and global focus (Forgione et al., 2020). In contrast, research on GCC banks has been limited. Although studies such as Srairi (2010), Alsharif (2020), and Srairi et al. (2022) have addressed cost-efficiency in the region, none have examined the role of ESG in explaining cost-inefficiency during the pandemic. This research addresses these gaps by providing new evidence from the GCC banking sector, using parametric and panel data analysis.

3. METHODOLOGY

The research sample consists of 46 commercial banks operating in the GCC. ESG variables were obtained from LSEG, bank-level variables from banks' annual report, and macroeconomic and institutional indicators from the World Development Indicator (WDI) database. For the sample selection, the research eliminates all non-commercial banks and Islamic banks, retaining only those with available and consistent financial data to ensure continuity and comparability in the analysis. Out of a total of 48 banks, only two were excluded due to undisclosed financial statements.

The efficiency of banks is determined by its ability to convert resources into income-generating financial assets at the lowest possible cost (Berger and DeYoung, 1997). Efficiency can be measured using parametric or non-parametric methods. Non-parametric methods, such as DEA and FDHA, are sensitive to noise and measurement errors because they do not distinguish between inefficiency and statistical noise (Liang et al., 2024). As a result, any error or random fluctuation is treated as inefficiency, leading to a distorted result (Algeri et al., 2025). Additionally, outliers pose a challenge in non-parametric measures, whereas parametric methods allow for controlling country-level effects in the main estimation frontier (Srairi, 2010). Moreover, the traditional accounting measures, such as cost-to-income, can also be misleading as they fail to capture the effect of inputs interactions (Chang et al., 2021). Therefore, this study employs the one-step SFA proposed by (Battese and Coelli, 1995). SFA estimates the distance of a bank from the "best possible" performance –the efficient frontier (Liang et al., 2024). The analysis adopts the intermediation approach, widely used in banking efficiency research. It specifies the translog cost function with three inputs –funds, capital and labor- and three outputs –loans, investment, and noninterest income (Liang et al., 2024). The model accounts for both random noise and inefficiency and allow for flexible substitution and interaction effects between inputs. In other words, if one input becomes more expensive, the bank can adjust by using more of another input, which is more realistic than the fixed substitution rates in Cobb-Douglas function (Algeri et al., 2025). Following Allen and Rai (1996), the analysis imposes linear homogeneity in input prices by normalizing all input prices relative to the price of labor. *Cost Function* (Eq 1):

$$
\begin{aligned}
\ln\left(\frac{TC_{it}}{P_{2it}}\right) &= \alpha_0 + \alpha_1 \ln Y1_{it} + \alpha_2 \ln Y2_{it} + \alpha_3 \ln Y3_{it} \\
&+\beta_1 \ln\left(\frac{P_{1it}}{P_{2it}}\right) + \beta_2 \ln\left(\frac{P_{3it}}{P_{2it}}\right) + \frac{1}{2}\alpha_{11}(\ln Y1_{it})^2 \\
&+\frac{1}{2}\alpha_{22}(lnY2_{it})^2 + \frac{1}{2}\alpha_{33}(lnY3_{it})^2 \\
&+\alpha_{12} lnY1_{it} lnY2_{it} + \alpha_{13} lnY1_{it} lnY3_{it} \\
&+\alpha_{23} lnY2_{it} lnY3_{it} + \frac{1}{2}\beta_{11}\left[ln\left(\frac{P1_{it}}{P2_{it}}\right)\right]^2 \\
&+\frac{1}{2}\beta_{22}\left[ln\left(\frac{P3_{it}}{P2_{it}}\right)\right]^2 \\
&+\beta_{12} ln\left(\frac{P1_{it}}{P2_{it}}\right) ln\left(\frac{P3_{it}}{P2_{it}}\right) + \phi_{11}\ lnY1_{it} \\
&\ln\left(\frac{P_{1it}}{P_{2it}}\right) + \phi_{12} lnY1_{it} ln\left(\frac{P3_{it}}{P2_{it}}\right) + \\
&\phi_{21} lnY2_{it}\ ln\left(\frac{P1_{it}}{P2_{it}}\right) + \phi_{22} lnY2_{it} \\
&ln\left(\frac{P3_{it}}{P2_{it}}\right) + \phi_{31} lnY3_{it}\ ln\left(\frac{P_{1it}}{P_{2it}}\right) \\
&+\phi_{32} lnY3_{it}\ ln\left(\frac{P3_{it}}{P2_{it}}\right) + \rho_t + v_{it} + u_{it}
\end{aligned}
$$

Where *TC* is the total cost of bank *i* at time *t*, *P1* is the price of funding; *P2* is the price of labor used for normalization, *P3* is the price of capital and other administrative and operational expenses. *Y1* presents the total loans, *Y2* is bank investments, and *Y3* presents non-interest income. $v_{it} \sim N(0,\sigma_v^2)$ is a symmetric noise term captures random shock, while $u_{it} \geq 0$ is one sided inefficiency term captures cost inefficiency, and ρ_t is year-specific time dummy. Then, following Alqahtani et al. (2017), and Forgione et al. (2020) the inefficiency term of u_{it} is regressed in the second stage on ESG bank level and macroeconomic determinants as follows (Eq 2):

$$
\begin{aligned}
u_{it} &= \delta_0 + \delta_1 ENV_{it} + \delta_2 SOC_{it} + \delta_3 GOV_{it} \\
&+\delta_4 NPLs_{it} + \delta_5 Cap_{it} + \delta_6 Size_{it} + \delta_7 GDP_t \\
&+\delta_8 Inf_t + \delta_9 COV_t + \omega_{it}
\end{aligned}
$$

After estimating the value of u_{it} –the inefficiency of bank i at time t- the analysis exponentiate the following value to get the cost efficiency score for each bank. (Eq.3):

$$CE_{it} = exp\left(-\hat{u}_{it}\right)$$

SFA analysis measures the inefficiency term in log form, thus, taking the exponential undoes the log, ensuring that the value in natural cost-efficiency units. $CE_{it} = 1$ means the bank is fully efficient and operates exactly on the cost frontier. $CE_{it} > 1$ means the bank is inefficient and spends more than necessary to produce output.

4. ESTIMATION AND ANALYSIS

Table 1 presents the descriptive statistics, including the mean, standard deviation, minimum, and maximum values of the key variables. The average total cost of bank is 12.8 (SD= 1.65). Output variable Y1 presents the total loans with mean of 15.67 and (SD = 2.09), Y1 is the largest output in the cost function, signifying that banks' rely more on intermediation activities rather than; Y2 investments 11.94 (SD = 1.93), and Y3 non-interest income 11.64 (SD = 1.81). Moreover, price of funding P1 has an average value of 0.011 (SD = 0.01). P1 is highly dependent on the level of credit risk in the region (Alsharif, 2020). In contrast, P2 the staff and personnel expenses have a mean of 0.032 (SD = 0.04), while P3 captures the price of capital and other administrative expenses with mean of 0.02 (SD = 0.01). Notably, the highest cost component is the staff expenses; this indicates that banks are strategically investing in their human capital to enhance workforce capabilities. Alternatively, it could reflect inefficiencies or resource misallocation within operational activities (Al-Kubaisi and Khalaf, 2025). Aggregated ESG activities levels appear to be below the moderate threshold, with an average score of 0.41 (SD = 0.15), reflecting a lower emphasis of sustainability practices. The average environmental score is relatively low at 0.19 (SD = 0.20), the social pillar averages 0.38 (SD = 0.16), governance pillar shows the highest at 0.56, with (SD = 0.20). These variations suggest differing levels of emphasis across the ESG dimensions among GCC banks (Srairi, 2024). Non-performing loans average 0.065 (SD = 0.08), the mean capital ratio and bank size is 0.16 and 16.39 (SD = 0.10 and 1.78).

Table 2 presents the relationship between bank inefficiency– measured from Table 3- and its determinants. Notably, bank inefficiency exhibits a positive and significant correlation with capital 0.16, and size 0.05. This reflects the complexity associated with larger size and capitalized banks in allocating resources, which require higher monitoring costs (Boyd and Nicolo, 2005; Al-Gasaymeh, 2020). Aggregated ESG activities are positively correlated with operational inefficiency 0.14, size 0.078, and GDP 0.06. While larger size banks tend to expand ESG initiatives, this expansion may potentially increase operational complexity. GDP growth often comes with increased regulatory attention

Table 1: Descriptive statistics

Variable	Mean	Standard deviation	Min	Max
TC	12.88	1.65	8.10	17.49
Y1	15.67	2.09	9.98	19.20
Y2	11.94	1.93	5.55	15.31
Y3	11.64	1.81	5.51	15.23
P1	0.011	0.01	0.00	0.10
P2	0.032	0.04	0.00	0.48
P3	0.02	0.01	0.00	0.14
ESG	0.41	0.15	0.06	0.81
E	0.19	0.20	0.00	0.84
S	0.38	0.16	0.08	0.93
G	0.56	0.20	0.03	0.94
NPLs	0.065	0.08	0.00	0.55
Size	16.39	1.78	12.70	19.60
Capital	0.16	0.10	0.01	0.69
GDP growth	0.017	0.04	−0.08	0.07
Inflation	0.013	0.063	−0.01	0.026

and stakeholder expectations, prompting banks to improve ESG practices (Forgione et al., 2020). Conversely, non-performing loans and bank size are negatively and significantly correlated at −0.41. The COVID-19 dummy is associated with increases in bank inefficiency 0.23, minimal ESG engagement 0.02, and non-performing loans 0.10. However, these increases are statistically insignificant, suggesting the need for further investigation into the determinants of bank inefficiency and its interactions.

Table 3 presents the results of the one-step Stochastic Frontier Analysis (SFA) and GLS regression. The cost function models the log of total costs normalized by the labor price; each coefficient reflects the elasticity of cost with respect to a variable, as the model is in logarithmic form (Liang et al., 2024). Overall, the model demonstrates a good fit, with a log-likelihood value of (916.75) and a highly significant Wald Chi-square (680.45 $P < 0.01$). The inefficiency variance parameters ($\sigma_v^2 = 0.016$, $\sigma_u^2 = 0.011$) and the gamma ratio ($\lambda = 0.714$) further confirm the model's validity with 71% of variations are attributable to inefficiency rather than random noise. In terms of output elasticities, the coefficient for total loans volume ($ln\ Y1_{it}$) is positive and significant, (0.087). Higher lending volume is associated with more operational disruption, potentially due to the high monitoring costs –consistent with (Srairi, 2010 and Alsharif, 2020), where they reported that output loan is a primary cost driver in GCC banks. Conversely, the investment output ($lnY3_{it}$) is negative and significant (−0.050). However, ($lnY3_{it}$) the increase in non-interest activities is positive but statistically insignificant (0.011); fee-based activities have a limited influence on bank cost, potentially due to the excessive focus on intermediation output. This finding resonates with Forgione et al. (2020) who noted that non-intermediation activities require technological readiness and developed framework.

In terms of input prices effects, the price of funding relative to labor (β_1 = 0.025), and the price of capital relative to labor (β_2 = 0.018) both demonstrate a positive and significant effects on total costs. These results imply that increases in funding and capital prices contribute directly to higher costs levels; meanwhile they also reflect how sensitive the GCC banks to external market conditions. In particular, the significance of funding costs underscores the dependence of GCC banks on the deposits market (Alsharif, 2020). Therefore, ESG integration at this stage is helpful due to its contribution to bank risk concentration and diversity of income generating activities rather than funding and capital reliance. The second-order terms of output variables $\frac{1}{2}\alpha_{11}, \frac{1}{2}\alpha_{22}, \frac{1}{2}\alpha_{33}$, all demonstrate a negative and significant effect on costs, indicating diminishing returns to scale in output production. In other words, as banks expand output, the marginal costs of producing additional output decreases at a decreasing rate, pointing to the existence of cost economies of scale. Hence, as bank increases its level of lending –or investment and NOI- the average costs per unit declines. Large banks can spread their fixed costs over a larger volume, this result in a lower marginal costs comparing to smaller banks –consistent with (Al-Gasaymeh, 2020; Algeri et al., 2025). While the cross-output interactions of loans and non-interest income (α_{13} = 0.168) is positive and significant, suggesting a trade-off, banks expanding both intermediation and

Table 2: Pairwise correlation matrix

	u_{it}	ESG	NPLs	CAP	SIZE	GDP	INF	COV
u_{it}	1.000							
ESG	0.14**	1.000						
NPLs	0.01***	0.091	1.00					
CAP	0.16***	0.005	0.38***	1.00				
SIZE	0.05***	0.078**	−0.41***	−0.52***	1.00			
GDP	−0.02	0.064*	−0.060	0.009	−0.00*	1.00		
INF	0.09	0.052	−0.11	−0.010	0.139*	0.37***	1.000	
COV	0.23	0.025	0.100	−0.053	−0.016	−0.45***	0.031	1.000

Standard errors are in parentheses: *p<0.10, **p<0.05, and ***p<0.01.

Table 3: Stochastic frontier half-normal and GLS regression

Output *y*	Coefficient
$\alpha_1 \, lnY1_{it}$	0.087*** (0.019)
$\alpha_2 \, lnY2_{it}$	−0.050*** (0.015)
$\alpha_3 \, lnY3_{it}$	0.011 (0.021)
$\beta_1 \ln\left(\frac{P_{1it}}{P_{2it}}\right)$	0.025*** (0.010)
$\beta_2 \ln\left(\frac{P_{3it}}{P_{2it}}\right)$	0.018* (0.009)
$\frac{1}{2}\alpha_{11}(\ln Y1_{it})^2$	−0.056*** (0.024)
$\frac{1}{2}\alpha_{22}(lnY2_{it})^2$	−0.019** (0.009)
$\frac{1}{2}\alpha_{33}(lnY3_{it})^2$	−0.060*** (0.027)
$\alpha_{12} \, lnY1_{it} \, lnY2_{it}$	−0.083*** (0.034)
$\alpha_{13} \, lnY1_{it} \, lnY3_{it}$	0.168*** (0.036)
$\alpha_{23} \, lnY2_{it} \, lnY3_{it}$	−0.008*** (0.002)
$\frac{1}{2}\beta_{11}\left[ln\left(\frac{P1_{it}}{P2_{it}}\right)\right]^2$	−0.001 (0.001)
$\frac{1}{2}\beta_{22}\left[ln\left(\frac{P3_{it}}{P2_{it}}\right)\right]^2$	−0.036** (0.017)
$\beta_{12}ln\left(\frac{P1_{it}}{P2_{it}}\right)ln\left(\frac{P3_{it}}{P2_{it}}\right)$	0.001 (0.000)
$\phi_{11} \, lnY1_{it} \ln\left(\frac{P_{1it}}{P_{2it}}\right)$	0.002 (0.000)
$\phi_{12} lnY1_{it} ln\left(\frac{P3_{it}}{P2_{it}}\right)$	0.005 (0.003)
$\phi_{21} lnY2_{it} \, ln\left(\frac{P1_{it}}{P2_{it}}\right)$	0.033** (0.016)
$\phi_{22} lnY2_{it} \, ln\left(\frac{P3_{it}}{P2_{it}}\right)$	−0.012 (0.011)
$\phi_{31} lnY3_{it} \, ln\left(\frac{P_{1it}}{P_{2it}}\right)$	0.089 (0.080)
$\phi_{32} lnY3_{it} \, ln\left(\frac{P3_{it}}{P2_{it}}\right)$	0.015*** (0.010)

(*Contd...*)

Table 3: (*Continued*)

Output *y*	Coefficient
Cons.	1.088*** (0.002)
σ_v^2	0.016*** (0.001)
σ_u^2	0.011*** (0.002)
λ	0.714*** (0.002)
Log likelihood	916.75
Wald Chi-square (19)	680.45
Prob > Chi-square	0.000
Inefficiency model u_{it}	
ENV	0.004*** (0.001)
SOC	0.003 (0.002)
GOV	0.003** (0.001)
NPLs	0.023 (0.146)
Capital	0.470*** (0.170)
Size	0.023*** (0.011)
GDP	0.001 (0.000)
INF	0.000 (0.001)
COVID	0.078*** (0.028)
Constant	−0.297** (0.197)
σ_u^2	0.29
σ_e^2	0.12
Adj-R square	0.22
Observations	240
Prop > Chi-square	0.002

Standard errors are in parentheses: *p<0.10, **p<0.05, and ***p<0.01.

fee-based activities may face higher complexity and inefficiencies. This finding is critical in the GCC where the financial framework and technological infrastructure still lag, hampering the opportunity to diversify output, in line with (Aldousari and Alsabah, 2025; ElAlfy et al., 2025). Overall, the high and significant value of λ (0.714) confirms the relevance of the stochastic frontier approach in determining how inefficiency accounts for a substantial portion of the variations in the operational costs. The findings from Table 3 confirms that strong inefficiency component in emerging markets is due to managerial heterogeneity and varying institutional environments (Chang et al., 2021). The SFA findings also confirm that banks exhibit moderate to low cost-efficiency level (Table 4) due to the reliance on traditional lending and capital reliance.

Since the estimation of $\hat{u}$ requires a second step regression on other covariates (Greene, 2002). The research followed Demirgüç-Kunt and Huizinga (2010) in employing the GLS model after estimating the inefficiency term, as this method adjust heteroskedasticity and offer reliable coefficient estimates (Baltagi and Li, 2004). Environmental activities show a positive and significant impact

Table 4: Cost-efficiency scores

Bank	ID	Country	CE_{it}
Ahli Bank of Kuwait	ABK	Kuwait	34.924
Ahli Bank of Oman	ABO	Oman	35.424
Ahli Bank of Qatar	ABQ	Qatar	46.927
UBAF Arab International Bank	AAIB	Bahrain	33.617
Abu Dhabi Commercial	ADCB	UAE	41.057
Ajman Bank	AJJB	UAE	32.960
Arab National Bank	ANB	Saudi Arabia	45.308
Bank of Bahrain and Kuwait	BBBK	Bahrain	34.838
Burgan Bank of Kuwait	BBK	Kuwait	27.026
Credit Bank	BCB	Bahrain	24.647
Bahrain Development Bank	BDD	Bahrain	25.985
Bank Dhofar	BDO	Oman	31.622
ALSalam Bank	BMI	Bahrain	29.665
Bank of Muscat	BMO	Oman	34.856
Banque Saudi France	BSFS	Saudi Arabia	42.352
Bank of Sharjah	BSH	UAE	28.559
Commercial Bank of Dubai	CBDD	UAE	40.796
Commercial Bank of Qatar	CBQ	Qatar	33.929
Commercial Bank of Kuwait	CBK	Kuwait	35.360
Doha Bank	DBQ	Qatar	37.502
Emirates Investment Bank	EMI	UAE	28.199
Emirates NBD	ENBD	UAE	39.576
First Bank Abu Dhabi-United	FBAD	UAE	46.625
Gulf Bank of Kuwait	GBK	Kuwait	36.122
Gulf Financial House	GFH	Bahrain	26.156
Gulf International Bank	GIB	Bahrain	33.125
Industrial Bank	IBKI	Kuwait	22.519
Invest Bank	IBU	UAE	29.172
AL Jazeera Bank	JBS	Saudi Arabia	34.721
National Bank of Bahrain	NBB	Bahrain	38.403
National Bank of Fujairah	NBFU	UAE	35.425
National Bank of Kuwait	NBK	Kuwait	38.500
National Bank of Oman	NBO	Oman	30.390
National Bank Ras AL Khaimah	NBRK	UAE	37.269
National Bank Um AL Qaiwain	NBUM	UAE	49.477
Qatar National Bank	QNB	Qatar	47.059
AL Rajhi Bank	RAJJ	Saudi Arabia	45.589
Riyadh Bank	RBS	Saudi Arabia	44.406
SAMBA	SAM	Saudi Arabia	31.500
National Commercial Bank	SANB	Saudi Arabia	46.442
Saudi Awal Bank	SAWS	Saudi Arabia	40.535
Sohar International Bank	SIBB	Oman	33.199
SICO Bank	SIB	Bahrain	26.482
Saudi Investment Bank	SIVB	Saudi Arabia	35.403
United Arab Bank	UARB	UAE	27.837
United Gulf Bank	UGB	Bahrain	17.378
Total			35.193

on bank inefficiency ($\beta = 0.004$, $\rho < 0.1\%$). In regions such as the GCC, where limited farmland and high temperatures constrain environmental conditions, implementing environmental initiatives may increase operational costs, as the benefits of such activities often take time to appear. Consequently, these initiatives are associated with higher inefficiencies, diverting bank resources out of investment in the short-term, consistent with (Demers et al., 2020; Folger-Laronde et al., 2022). The social component demonstrates a positive effect; however its impact is statistically insignificant. Weak social responsibility practices can negatively affect banks' asset quality, thereby undermining their ability to convert resources efficiently, consistent with (Ali et al., 2024). The governance pillar has a positive and significant impact on inefficiency ($\beta = 0.003$, $\rho < 0.05\%$). Weak governance performance is associated with higher operational inefficiencies. In the GCC, governance challenges – such as limited accountability and disclosure- combined with social constraints, contribute to inefficient operations and misallocation of resources. This differs from the findings of López-Penabad et al. (2023) who observed a negative indicator of social activities and governance with inefficiency in Europe. Banks with higher ratios of NPLs and capital tend to have lower efficiency, particularly during crisis periods (Berger and Bouwman, 2013). For the COVID-19 dummy, NPLs, and capital, a positive impact on inefficiency is observed ($\beta = 0.07$, $\beta = 0.02$, $\beta = 0.47$, $\rho < 0.01\%$). The capital reliance during the pandemic is associated with financial fragility and operational weakness, inconsistent with (Alqahtani et al., 2017; Alsharif, 2020; Srairi, 2010). Banks with weak governance struggle to monitor both their costs and loans portfolio (Berger and DeYoung, 1997). Size also shows a positive and significant impact on inefficiency, specifically, a 1% increase in size is associated with 0.023 increases in inefficiency. Hence, bank efficiency is highly vulnerable by size and complexity, consistent with (Al-Gasaymeh et al., 2020).

Al-Hiyari et al. (2023) discussed that the recent ESG adherence may improve operational efficiency. This holds true in the start-up phase –for social and governance indicators- where the ESG implementation tend to attract attention, as they are easy to achieve, while more advanced ESG are costly and require specialized expertise (Kotsantonis et al., 2016). In Figures 1-3, a notable pattern emerges regarding the relationship between ESG components and bank inefficiency. When E, S, and G scores are 20, the inefficiency scores are relatively low – 0.25 (E), 0.23 (S), and 0.22 (G), suggesting that the initial phase involve relatively low inefficiency, since early-stages of ESG practice are limited in scope and less complex to implement. However, as banks deepen their engagement –reaching a scores of 40- the inefficiency scores rise to 0.26 (S), and 0.27 (G), but a slight decrease with 0.22 (E) is noticed, suggesting that environmental activities often yield quick operational benefits, while social and governance efforts involves higher costs that can temporarily reduce efficiency before long-term gains appears, in line with (Yuen et al., 2022). Such a scenario is particularly relevant for the GCC banking sector, where ESG frameworks are relatively emerging, and banks may lack the technical capacity to fully implement the practice efficiently. Interestingly, when the scores reach 80, inefficiency scores decline significantly to 0.12 (E), 0.18(S), and 0.21(G). Hence, once ESG practices are fully integrated with bank operations, they can contribute to improved cost-efficiency. Although the transition phase may be costly, the eventual payoffs include operational efficiency and enhanced sustainable performance.

Table 4 presents the cost-efficiency (CE) scores of GCC banks estimated using the SFA model described in Table 3. The results show that CE values range from 0.17 to 0.49, with a mean efficiency of 0.35, indicating that, on average, banks in the region operate at only 35% of the cost-efficiency frontier. Across countries, Saudi Arabian, UAE and Qatari banks exhibit higher efficiency levels, particularly for banks as ABQ, ANB, FBAD, NBUM, QNB, RAJJ, and SANB. However, there remains considerable room for improvement, as the efficient frontier is 65% away. This gap could potentially be reduced by integrating ESG

Figure 1: Environmental pillar scores and bank inefficiency

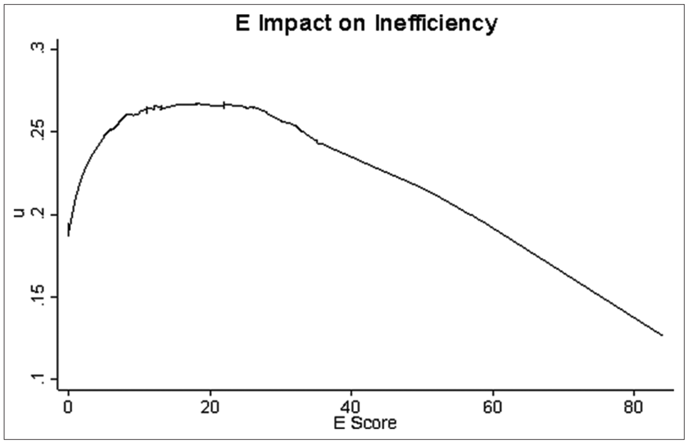


Figure 2: Social pillar scores and bank inefficiency

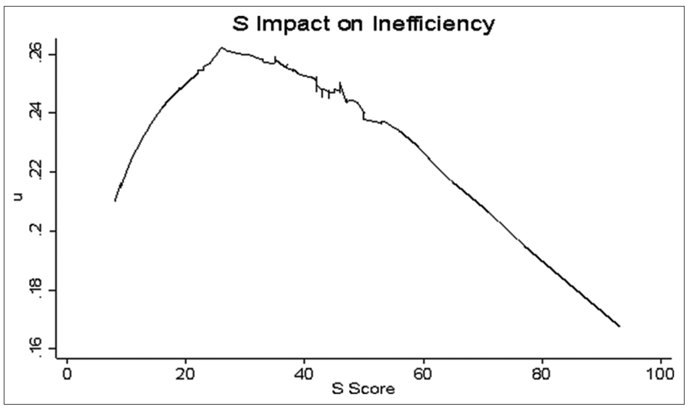
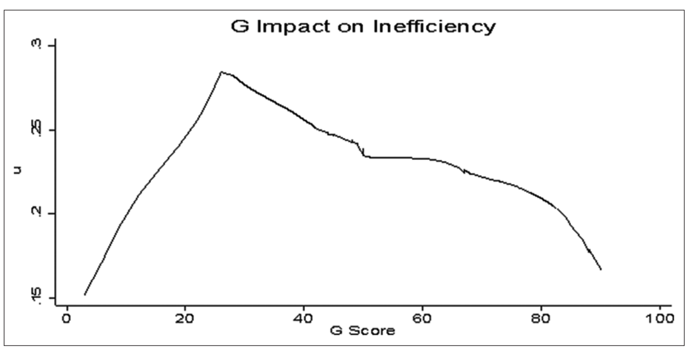


Figure 3: Governance pillar scores and bank inefficiency



factors into banks' business transformation functions to enhance resource allocation effectively. Compared with previous studies that employed the traditional cost function in the GCC context, Hadhek et al. (2018) reported an average CE level of 0.25, Miah and Uddin (2017) found a level of 0.37, while Alqahtani et al. (2017) observed CE levels of 0.46 for Islamic banks, and 0.49 for commercial banks. However, all of these studies were conducted prior to the pandemic and relied on the DEA methodology, which lacks the ability to account for stochastic noise (Liang et al., 2024).

4.1. Robustness Checks

To validate the main findings, the research employs a robustness checks using truncated regression, following the approach of Simar and Wilson (2007) and Chang et al. (2021). This method is commonly adopted as a second-stage procedure to assess the determinants of efficiency scores. Unlike OLS, which is inappropriate in this context due to the non-negative nature of the inefficiency score, truncated regression is suitable as it accounts for the censored nature of the dependent variable $-u_{it}$ which cannot be negative. While the main results relied on GLS regression, the truncated regression complements them by offering robustness and addressing the potential bias from using a constrained dependent variable, as also emphasized by (Alqahtani et al., 2017). Since truncated model does not correct for heteroskedasticity, the Breusch-Pagan test was conducted and showed no evidence of heteroskedasticity – P = 0.15. In addition, a variance inflation factor analysis confirmed the absence of multicollinearity with mean of 1.44.

The robustness analysis in Table 5 extends the baseline GLS model by including interaction terms, allowing the analysis to explore how the disaggregate ESG pillars interact with contextual factors. Specifically, the model examines how environmental, social, and governance pillars interact with institutional quality factors (IQF). These elements serve as the mechanisms through which ESG factors influence actual risk outcomes, making their inclusion crucial for a meaningful analysis (Almulla et al., 2025). Examining the ESG and efficiency relationship requires capturing the IQF – such as government effectiveness, regulatory law, control for corruption, and political instability. The environmental interaction term shows a positive and significant impact on inefficiency ($\beta = 0.049$, $\rho < 0.05\%$). Strong IQF promotes greener outcomes, even if such initiatives temporarily increase operational costs, reflecting a green-efficiency trade-off. Given that the RE model captures short-term dynamics, environmental outcome may require a longer period to appear –especially in the GCC, where the green infrastructure remains limited, in line with Yuen et al. (2022), but differs from the findings of (Almulla et al., 2025). Moreover, once institutional factors are integrated, the social and governance impact reversed to negative and significant on inefficiency ($\beta = -0.189$, $\rho < 0.1\%$; $\beta = 0.005$, $\rho < 0.10\%$). These findings indicate that social and governance factors contribute to reducing inefficiencies when institutional factors are controlled (ElAlfy et al., 2025). Additionally, bank size and diversification show a positive and significant effect on inefficiency ($\beta = 0.261$, $\rho < 0.10\%$), consistent with our main results, suggesting that expanding both size and fee-based activities increase operational complexity. The COVID-19 dummy also shows a positive and significant effect, while the capital ratio exhibits a negative effect. This indicates that the pandemic adversely affected bank efficiency, while capital ratio played a significant role in mitigating inefficiency, reflecting policy intervention responses to external shock. Overall, the robustness checks confirms that in the RE model we show the short-term pure positive impact. Conversely, in the TR after controlling for IQF, the effect moderates, indicating a non-linear relationship between ESG practices and inefficiency, particularly when supported by strong institutional quality.

Table 5: Truncated regression

u_{it}	Coefficient
ENV×IQF	0.049**
	(0.023)
SOC×IQF	−0.189***
	(0.062)
GOV×IQF	−0.005*
	(0.003)
Diversification	0.261*
	(0.180)
Capital	−0.708***
	(0.257)
Size	0.931***
	(0.016)
GDP	−0.025***
	(0.006)
INF	0.001
	(0.003)
COV	0.193**
	(0.089)
Cons.	−0.776**
	(0.432)
Log Likelihood	16.34
σ	0.198
	(0.015)***
Prob > Chi-square	0.000

5. CONCLUSION

This research examines the impact of ESG activities on bank cost-inefficiency for 46 commercial banks operating in the GCC during 2018-2022. The methodology part was based on one-step SFA, the main analysis was based on GLS and for robustness checks, the truncated regression was utilized. The study is implemented since the reliance on intermediation activities was heightened previously in the region, leading banks to neglect the ESG sustainable activities which is characterized as a strategic tool against risk-taking and inefficiency.

The research finds that the impact of disaggregate ESG factors on cost-inefficiency is context dependent. The main analysis found that the ESG components are all associated with higher inefficiency. ESG efforts are costly in the short-term to medium, unless well-integrated into bank operations. While in the robustness model, we found that the stronger institutional quality increases environmental costs, institutions may enforce rules strictly, but banks might struggle to adapt, leading to resource diversion to meet regulatory requirements instead of innovation. We find also that social and governance activities became cost-efficiency tools once interacted with strong institutional quality factors. These interactions reveal that ESG impact are not uniform, they are context dependent. The outcomes depend on internal and external factors –such as institutional quality factors and crises. Hence, the ESG factors effect is conditional, and governance element can reverse the inefficiency indicator with respect to the event. Supporting this, the visual analysis in Figures 1-3 which reveal that inefficiency remains relatively low during the early stages of ESG implementation. As ESG scores reach moderate levels, inefficiency increases, particularly for social and governance factors. However, at advanced stages, inefficiency declines. Therefore, long-term benefits emerge when ESG factors are fully integrated into bank operations. To enhance efficiency, banks must go beyond adopting ESG practice for compliance. Instead, they should operate with a serious commitment to sustainability, invest in human capital, and strategically integrate ESG into their core business model.

This research has certain limitations, notably, the study period is within 2018-2022 corresponds with the pandemic and the persistence effect of previous inefficiencies. Future research could benefit from including the post-pandemic data to capture the long-term effect. Additionally, employing meta-frontier analysis to assess the technological gap along with a qualitative survey –particularly for investors- would provide valuable findings into how the ESG activities satisfy stakeholders; this would further enrich the GCC literature.

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