

Internal Audit Quality and Green Lending: Strengthening Low-Carbon Environmental Performance in Indonesian Listed Commercial Banks

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Abstract

The transition toward a low-carbon economy has increased the importance of sustainable finance and effective corporate governance within the banking industry. Green lending has become a key financing strategy for supporting environmentally sustainable investments; however, prior studies have largely examined internal governance and green lending separately, leaving limited evidence on whether Internal Audit Quality can strengthen the environmental effects of green lending. This study examines the effects of Internal Audit Quality (IAQ) and Green Lending (GL) on Low-Carbon Environmental Performance (LCEP) and investigates whether IAQ strengthens the relationship between GL and LCEP in Indonesian listed commercial banks. Using a quantitative research design, this study analyzes panel data from 47 Indonesian listed commercial banks during 2020–2024, resulting in 235 firm-year observations. The hypotheses are tested using a Fixed Effect Model (FEM) following panel model selection tests. IAQ is measured using a disclosure-based index, GL is measured by the proportion of green financing, and LCEP is measured using a composite disclosure index reflecting banks' environmental commitments and low-carbon initiatives. The results indicate that IAQ has a positive and significant effect on LCEP ($\beta = 0.367$, $p = 0.0001$), while GL also has a positive and significant effect on LCEP ($\beta = 0.298$, $p = 0.0002$). Furthermore, the interaction between IAQ and GL is positive and significant ($\beta = 0.184$, $p = 0.0061$), indicating that higher IAQ strengthens the positive effect of GL on LCEP. These findings highlight the strategic role of internal auditing in strengthening governance and supporting sustainable finance implementation. The study contributes to the sustainable finance and corporate governance literature by integrating IAQ and GL within a unified framework to explain LCEP in emerging-market banking institutions.

KEYWORDS

internal audit quality; green lending; low- carbon environmental performance; sustainable finance; banking sector

Introduction

Climate change has become one of the greatest global problems in recent times as it is undermining the sustainability of the environment, economic resiliency, and well-being of societies. GHG emissions, global warming, loss of biodiversity, and the increasing occurrence of natural disasters have spurred international efforts towards sustainable development and transition to a low-carbon economy. Such efforts are seen in the Paris Climate Change Agreement and UN Sustainable Development Goals that call on governments, firms, and financial institutions to incorporate environmental sustainability into their decision-making and corporate governance processes. Financial institutions such as banks play an important role in climate change mitigation due to the responsibility to channelize capital to economic activities based on environmental sustainability principles and away from carbon-intensive projects ([Intergovernmental Panel on Climate Change, 2023](#); [United Nations Environment Programme Finance Initiative, 2023](#)).

In this context, sustainable finance has emerged as one of the major policy agendas around the world, with emphasis on the incorporation of ESG considerations in financial decisions and banking activities (Adu & others, 2025; Ainunnisa et al., 2024). Various kinds of sustainable finance tools have been developed; however, in recent years, growing focus has been observed for green lending, as through green lending financial resources are directed towards renewable energy, clean technology, sustainable infrastructure, and environmentally sound businesses. Other than encouraging environmental sustainability, green lending also helps in reducing climate related financial risks (Bose et al., 2022; Ozili, 2023; Y. Zhang et al., 2024). Green lending is now not only seen as an exercise in corporate social responsibility but also as a strategy that can create both environmental and economic value at once.

This commitment has been evident through the promulgation of Financial Services Authority Regulation (POJK) No. 51/POJK.03/2017 on the application of sustainable finance in financial service institutions, issuers, and public companies. The regulation stipulates that the sustainability concept should be applied in governance, business strategies, risk management, and financing processes of banks. Another evidence is the Sustainable Finance Roadmap Phase II (2021-2025) which promotes sustainable financing, effective climate risk management, and good environmental governance for the realization of Net Zero Emissions by 2060 (Otoritas Jasa Keuangan, 2021). All these regulatory measures have helped place the Indonesian banking industry among the key catalysts for the sustainable transformation of the economy.

While sustainable finance has increased considerably in Indonesia, there are still doubts about whether the expansion of green lending has been instrumental in delivering real environmental benefits. Existing literature shows that green lending is instrumental for environmental sustainability through investment in renewable energy, energy efficiency improvement, and reduction of carbon emissions (Bose et al., 2022; Hussain et al., 2024; D. Zhang et al., 2023). However, the results of empirical studies also show that the efficiency of green lending varies significantly among banks, as it requires not only finances but also good governance and risk management practices (Naqvi et al., 2023; Ozili, 2023). These discrepancies show that sustainable finance in itself is inadequate in ensuring good environmental performance, without any internal governance system (Nagina, 2025; Thapliyal et al., 2025).

Governance is known for being a major determinant of accountability and sustainability of organizations. Various governance tools exist, and IAQ has transformed from its traditional focus on compliance to a strategic assurance approach that enhances the efficiency of governance, risk management, and internal control. According to the Institute of Internal Auditors (Institute of Internal Auditors, 2024), internal auditing provides independent and objective assurance designed to improve organizational operations by evaluating governance, risk management, and control processes. The Institute of Internal Auditors (Institute of Internal Auditors, 2024) further broaden this responsibility by focusing on risk assessment, particularly of emerging risks, which may include climate risks, ESG management, sustainability reporting, and environmental compliance. As a result, Internal Audit has evolved into a critical governance tool for promoting sustainable operations in organizations.

There are several theoretical approaches explaining the strategic significance of Internal Audit Quality. The first is the Agency Theory, which states that internal audit of high quality decreases information asymmetry between the manager and shareholders because it increases monitoring and transparency and lowers agency costs (Jensen & Meckling,

1976). According to Stakeholder Theory, organizations should generate value not just for their shareholders but also for their regulators, investors, customers, employees, and the general public as well, who are becoming more aware of their responsibility towards the environment (Freeman, 1984). Moreover, Institutional Theory argues that organizations constantly adjust their governance systems in reaction to regulatory, professional, and social pressures, especially with regards to the growing presence of sustainable finance regulations and ESG disclosures (DiMaggio & Powell, 1983). Together, these theories indicate that Internal Audit Quality will enhance the efficacy of green lending through increased governance quality, environmental regulation, and accountability (Isack & Aschauer, 2025; Purnamasari & Umiyati, 2024).

Empirical evidence from recent years proves the importance of the increasingly strategic nature of internal auditing in fostering sustainability of governance. Empirical research has shown that quality internal auditing improves corporate governance, internal controls, enterprise risk management, and transparency (Abbott et al., 2016; Christ et al., 2021; Eulerich et al., 2022). More recent literature also indicates that internal auditors are becoming actively involved in evaluating ESG implementation, climate-related risks, sustainability reporting, and environmental governance (Deloitte, 2023; KPMG, 2024). By providing independent assurance and continuous monitoring, internal audits ensure the credibility of sustainable finance implementation and avoid the symbolic nature of sustainability programs being used only for compliance purposes. Hence, Internal Audit Quality should positively influence the effectiveness of green lending on banks' Low-Carbon Environmental Performance.

Although there is an ever-growing body of literature about sustainable finance and corporate governance, several research gaps need to be addressed. The first gap concerns the lack of research that explores green lending and Internal Audit Quality in a joint context. Although the topic of sustainable finance has been mostly concerned with the effects of green lending, ESG disclosures, and sustainable finance policy on financial and environmental performance, research on internal audit has paid more attention to governance effectiveness, fraud detection, internal control systems, and financial reporting quality. Thus, empirical evidence explaining the relationship between Internal Audit Quality and the effectiveness of green lending in terms of Low-Carbon Environmental Performance is scarce. Especially in developing countries like Indonesia, where the regulation of sustainable finance is constantly changing and banks need to improve environmental governance while preserving their financial stability.

Building upon these developments, recent studies have consistently demonstrated that green lending contributes to renewable energy investment, environmental innovation, carbon emission reduction, and sustainable economic development (Batten et al., 2021; Bose et al., 2022; Hussain et al., 2024; Jahanger et al., 2024; D. Zhang et al., 2023). Likewise, the internal auditing literature has evolved considerably from emphasizing financial assurance toward broader governance responsibilities, including enterprise risk management, ESG assurance, and sustainability oversight (Christ et al., 2021; Drogas et al., 2023; Eulerich et al., 2022). While both branches of literature have grown considerably, there is an evident gap between them. In general, sustainable finance literature tends to study how green lending affects either environment-related results or financial ones, while internal audit literature is mostly concerned with governance effectiveness, high-quality internal controls, prevention of fraud, and the reliability of financial reports. As a result, little work has been done on the interaction between IAQ and sustainable finance initiatives to enhance the environmental

performance.

A thorough review of existing literature shows that there are some issues that remain unresolved. Firstly, the majority of sustainable finance literature assumes that an increase in green lending leads to better environmental performance (Hermawan & Khoirunisa, 2024). Yet, green lending depends significantly on governance within organizations, internal controls, the assessment of environmental risks, and the observance of sustainability legislation. In case governance is weak, an increase in green lending can lead only to a higher number of environmentally-oriented financing but not necessarily to the reduction of carbon footprint or other improvements in environmental sustainability. It means that the risk of greenwashing will be higher (Delmas & Burbano, 2011; Lyon & Montgomery, 2015).

Second, governance research has historically used indicators such as the board characteristics, ownership structure, effectiveness of audit committees, and quality of the external audit as proxy measures of governance mechanisms that promote corporate sustainability. Little has been done with regards to the topic of Internal Audit Quality even though this is the only independent assurance activity that provides evaluations of governance performance, enterprise risk management, and internal controls. The Global Internal Audit Standards (Institute of Internal Auditors, 2024) further strengthens the important role played by internal auditors in assessing ESG adoption, climate-related risks, and sustainability governance. Nonetheless, empirical evidence on how high internal audit quality positively impacts the effectiveness of green lending is sparse.

Third, prior empirical research has mostly been conducted in developed countries where practices related to ESG, climate change disclosures, and sustainable finance regulation are relatively advanced. In contrast, emerging countries, such as Indonesia, are operating in unique institutional contexts which are marked by evolving regulations, governance, and sustainable finance practices. As a result of the issuance of the Regulation of OJK No. 51/POJK.03/2017 and Sustainable Finance Roadmap Phase II (2021-2025), Indonesian commercial banks have considerably increased their sustainable financing activities. Yet, there are not many empirical research studies that have examined whether governance mechanisms such as Internal Audit Quality contribute to the success of green lending.

The next critical constraint is associated with measuring the outcomes of the research. The earlier research has used typical criteria such as profitability, company value, financial performance, efficiency, or quality of ESG disclosure to assess sustainable finance. Such criteria are still valuable; however, they offer a secondary measure of environmental sustainability. Fewer studies have measured Low-Carbon Environmental Performance as the main criterion of evaluation, although there is an increasing focus on the world for climate responsibility, lowering carbon emissions, and environmental governance. Measuring Low-Carbon Environmental Performance allows assessing the direct influence of banks on the shift towards low-carbon development.

Accordingly, the study addresses four main research gaps. Firstly, it fills in the theoretical gap by combining Internal Audit Quality and Green Lending into a corporate governance model of Low-Carbon Environmental Performance. Secondly, it fills in the empirical gap through a consideration of Internal Audit Quality not only as a governance characteristic but also as a strategic instrument in enhancing the effectiveness of green lending. Thirdly, it fills in the contextual gap through an empirical study of the Indonesian commercial banks which are regulated by a sustainable finance regulation system. Fourthly, it fills in the methodological gap through using Low-Carbon Environmental Performance as an environmental

outcome variable.

The main innovation of this research is related to the role of Internal Audit Quality as a strategic tool for governance that increases the efficiency of green lending for reaching environmental sustainability. Unlike many other papers that are dedicated to studying either the influence of green lending itself or corporate governance on environmental results, the current study analyzes the relationship between the quality of governance and sustainable finance. Thus, Internal Audit Quality can be expected to increase the efficiency of environmental risks evaluation, compliance with sustainable finance regulations, internal controls in green lending operations, and the credibility of environmental governance as well. The integration of Agency Theory, Stakeholder Theory, and Institutional Theory in one theoretical framework allows expanding the existing knowledge about sustainable finance and internal auditing.

This study offers a number of theoretical and practical contributions as well. On the theoretical front, the study adds to the sustainable finance literature by introducing Internal Audit Quality as one of the internal governance mechanisms that influence the success of green lending. The study adds value to internal audit literature by showing how the role of internal auditors goes beyond financial assurance into environmental governance and sustainable finance. From a practical standpoint, the results are expected to shed light on the importance of improving internal audit functions for better governance quality, better sustainable finance practice, and faster adoption of low carbon economy in Indonesia.

Based on the existing gaps in the literature and theory, the purpose of this study is to determine the impact of IAQ on LCEP, assess the impact of green lending on LCEP, and find out if IAQ enhances the relationship between green lending and LCEP of Indonesian commercial banks listed in the stock market within the period of 2020-2024. This study will add value to the field of governance, internal auditing, and sustainable finance literature by presenting empirical findings on how the interaction of governance and implementation of sustainable finance affects the environment.

Hypothesis Development

Internal Audit Quality and Low-Carbon Environmental Performance

Internal Audit Quality (IAQ) has now grown from an assurance and compliance activity to a strategic governance tool that is essential for organizational sustainability. As per the Global Internal Audit Standards (Institute of Internal Auditors, 2024), it is the job of internal auditors to assess the efficiency of governance, enterprise risk management, internal controls, and any other emerging risks, which includes ESG risks. IAQ improves the accountability of organizations as it ensures proper implementation of sustainability policies and proper management of environmental risks.

According to Agency Theory (Jensen & Meckling, 1976), internal audit serves as an instrument that lowers the level of information asymmetry between management and stakeholders through improvement of control mechanisms. Good internal audit decreases opportunistic behavior of management, compliance with environmental regulations, and transparency in sustainability reporting. Therefore, companies that have high level of Internal Audit Quality tend to take into account environmental issues when making decisions and conducting operations in order to achieve better Low-Carbon Environmental Performance.

Moreover, according to Stakeholder Theory (Freeman, 1984), it is important for an organization to consider needs of various stakeholders (regulators, investors, consumers, society). As the stakeholder expectations concerning environmental issues increase, internal audit plays an important role in the implementation of sustainability

commitments at the organizational level. There are some other empirical studies that have proven the positive effect of internal audit on corporate governance, risk management, ESG, and sustainability reporting (Christ et al., 2021; Drogalas et al., 2023; Eulerich et al., 2022). Thus, Internal Audit Quality positively influences Low-Carbon Environmental Performance.

Recent empirical evidence further suggests that Internal Audit Quality enhances ESG governance and sustainability assurance by improving environmental risk monitoring and governance effectiveness (Isack & Aschauer, 2025; Purnamasari & Umiyati, 2024). Therefore, high-quality internal audit functions are expected to improve Low-Carbon Environmental Performance.

H₁: Internal Audit Quality has a positive effect on Low-Carbon Environmental Performance.

Green Lending and Low-Carbon Environmental Performance

Green Lending is one of the critical sustainable finance tools used by banks to invest financial resources in environmentally friendly ventures such as renewable energy, energy efficiency, pollution control, and sustainable infrastructure projects. Through green lending, banks channel investments to environmentally friendly projects, which in turn help businesses develop more environmentally friendly technologies and lower greenhouse gas emissions.

According to Institutional Theory (DiMaggio & Powell, 1983), institutions change their behavior in response to regulatory, market, and social pressures. In Indonesia, where sustainable finance regulations have been put in place by the OJK, green lending will push banks to play an increasingly important role in meeting the national goal of low-carbon development.

Empirical data strongly suggest that green finance is an environmental benefit. Earlier researches show that green finance helps reduce carbon emissions, perform better environmentally, promote renewable energy production, and accelerate sustainable economic growth (Bose et al., 2022; Campiglio, 2016; Hussain et al., 2024; Jahanger et al., 2024; Naqvi et al., 2023). Banks, via sustainable capital investment, become direct contributors to environmentally friendly economic activities. Therefore, the adoption of green financing will lead to improvements in Low-Carbon Environmental Performance.

Recent empirical evidence suggests that green financing has become one of the main motivations for sustainable banking as it directs financial funds towards environmentally-friendly investments (Nagina, 2025; Thapliyal et al., 2025).

H₂: Green Lending has a positive effect on Low-Carbon Environmental Performance.

The Moderating Role of Internal Audit Quality

Although green lending has turned out to be a vital tool for fostering sustainable finance, its efficiency is significantly determined by the level of internal governance. Green financing of environment-friendly projects will not necessarily result in improved environmental performance unless complemented by proper monitoring, risk management, and regulation compliance. Poor governance can result in ineffective implementation of the environmental projects or even misuse of the green lending opportunities, thereby lowering the effect of green lending on the environment.

Quality Internal Audit contributes to efficient implementation of green lending through independent evaluation of environmental risk management, audit of sustainable finance regulations compliance, internal control assessment, and proper monitoring of green lending activities. The internal auditors are also able to give recommendations to improve governance and foster sustainability reporting credibility, thus reducing information

asymmetry.

From the point of view of Agency Theory, Internal Audit Quality supports the governance system through the reduction of agency problems related to sustainability projects. According to Stakeholder Theory, an efficient internal auditing process can increase the level of organization accountability to its stakeholders, whereas Institutional Theory postulates that internal audit allows for the adaptation of organizations to increasing sustainability requirements. Hence, Internal Audit Quality is expected to strengthen the positive association between Green Lending and Low-Carbon Environmental Performance as it helps implement and monitor sustainable financing practices.

Current research shows that governance systems have a significant effect on the effectiveness of sustainable finance strategies (Bose et al., 2022; Eulerich et al., 2022; Hussain et al., 2024). Thus, Internal Audit Quality can be considered as a strategic governance system supporting the effect of Green Lending on environmental performance.

H₃: Internal Audit Quality positively moderates the relationship between Green Lending and Low-Carbon Environmental Performance, such that the positive effect of Green Lending on Low-Carbon Environmental Performance becomes stronger when Internal Audit Quality is higher.

Methods

Research Type

This research utilizes a quantitative research design with panel data as its source of data to investigate the influence of IAQ and GL on LCEP in Indonesian commercial banks that are listed in the stock market. Panel data analysis was used since panel data consists of both cross-section and time series data, which facilitates better estimation as it controls both cross-sectional difference and changes over time (Baltagi, 2021). The current research concentrates on the 2020-2024 period, when Indonesia started to intensify the application of policies on sustainable finance through Sustainable Finance Roadmap Phase II.

Population and Sample/Informants

The population is comprised of all commercial banks listed at the Indonesia Stock Exchange (IDX). The sampling procedure utilized is purposive sampling since this will make the data more consistent and complete. The sampling criterias are:

1. Banks listed on the Indonesia Stock Exchange continuously during 2020–2024.
2. Banks publishing complete annual reports and sustainability reports throughout the observation period.
3. Banks providing sufficient information to measure Internal Audit Quality, Green Lending, and Low-Carbon Environmental Performance.
4. Banks with complete financial data for all control variables.

Based on these criteria, 47 listed commercial banks were selected, resulting in a balanced panel of 235 firm-year observations (47 banks × 5 years).

Data Source and Study Period

The secondary data used in this study consists of information from annual reports, sustainability reports, corporate governance reports, and financial statements collected from the Indonesian Stock Exchange website (www.idx.co.id) as well as the official websites of the selected banks. Information relating to regulations comes from OJK (Financial Services Authority) and other institutional publications.

Instrumentation or Tools

Low-Carbon Environmental Performance (LCEP)

The Low-Carbon Environmental Performance (LCEP) index is a disclosure-based index, based on sustainability reporting. The LCEP index assesses four different dimensions:

- Low-carbon strategy and policy;
- Energy efficiency initiatives;
- Green operational practices;
- Carbon emission reduction and environmental commitment.

Each disclosure item receives a score of 1 if disclosed and 0 otherwise. The index is calculated as:

$LCEP = \text{Number of disclosed items} / \text{Total disclosure items}$. Higher values indicate better low-carbon environmental performance.

Internal Audit Quality (IAQ)

IAQ refers to the use of an index that measures the quality of the internal audit practice based on the corporate governance and Global Internal Audit Standards (Institute of Internal Auditors, 2024). IAQ index is comprised of:

- Internal audit independence;
- Auditor competence and professional certification;
- Audit planning and implementation;
- Risk-based auditing;
- Audit committee interaction;
- Follow-up of audit recommendations;
- ESG and sustainability audit involvement.

Each indicator receives a value of 1 if disclosed and 0 otherwise. The Internal Audit Quality Index is calculated as:

$IAQ = \text{Number of disclosed indicators} / \text{Total indicators}$. Higher scores indicate stronger internal audit quality.

Green Lending (GL)

Green Lending (GL) represents the proportion of financing allocated to environmentally sustainable sectors. Following previous sustainable finance studies, Green Lending is measured as:

$$GL = \text{Green Financing} / \text{Total Financing}$$

Higher values indicate greater commitment to sustainable financing.

Control Variables

To reduce omitted-variable bias, several firm characteristics are included as control variables:

- Firm Size (SIZE): natural logarithm of total assets.

- Profitability (ROA): net income divided by total assets.
- Leverage (LEV): total liabilities divided by total assets.

These variables are widely recognized as determinants of corporate environmental performance.

Measurement of variables for the study has been chosen using a theoretical framework along with previous empirical works and the availability of disclosed information in the form of annual reports and sustainability reports (Table 1). As the study is related to the listed commercial banks in Indonesia, it was found that disclosure-based indices were the best way to measure the variables.

Data Analysis

Panel data regression was carried out using EViews 13. Three stages were involved in model selection. Firstly, the Chow Test was used to differentiate between the Common Effect Model and Fixed Effect Model. Secondly, the Hausman Test was used to choose between the Fixed Effect Model and Random Effect Model. Lastly, in cases where it is necessary, the Breusch-Pagan Lagrange Multiplier Test was done to differentiate between the Common Effect Model and Random Effect Model. The Fixed Effect Model was chosen as the best estimation method based on these tests.

Hypothesis testing was done after carrying out diagnostic tests which included tests for multicollinearity, heteroscedasticity, and autocorrelation. Multicollinearity does not exist if Variance Inflation Factor (VIF) values are less than 10 while heteroscedasticity and autocorrelation were tested using the Breusch-Pagan and Durbin-Watson statistics respectively. Furthermore, robustness tests involving Fixed Effect, Random Effect, and Pooled OLS estimations were carried out.

To examine the effects of Internal Audit Quality (IAQ) and Green Lending (GL) on Low-Carbon Environmental Performance (LCEP), including the moderating role of GL, this study employs a panel data regression model. The empirical model is specified as follows:

$$LCEP_{it} = \alpha + \beta_1 IAQ_{it} + \beta_2 GL_{it} + \beta_3 (IAQ_{it} \times GL_{it}) + \beta_4 SIZE_{it} + \beta_5 ROA_{it} + \beta_6 LEV_{it} + \mu_i + \varepsilon_{it}$$

where $LCEP_{it}$ represents the Low-Carbon Environmental Performance of firm i in year t ; IAQ_{it} represents Internal Audit Quality; GL_{it} represents Green Lending; $IAQ_{it} \times GL_{it}$ represents the interaction term between Internal Audit Quality and Green

Table 1. Measurement of Each Variable

No	Variable	Measurement	Indicator	Reference
1	Low-Carbon Environmental Performance (LCEP)	Disclosure Index	Four dimensions comprising 12 disclosure indicators. Each indicator is scored 1 if disclosed and 0 otherwise.	Bose et al. (2022); Hussain et al. (2024); X. Zhou et al. (2023)
2	Internal Audit Quality (IAQ)	Disclosure index	Independence, competence, audit planning, risk-based audit, audit committee, ESG assurance, follow-up	Institute of Internal Auditors (2024); Eulerich et al. (2022); Drogas et al. (2023)
3	Green Lending (GL)	Ratio of green financing to total credit provided by the bank.	(1) Financing for renewable energy projects (2) Financing for energy efficiency (3) Sustainable infrastructure financing (4) Environmentally friendly project loans	Campiglio (2016); Bose et al. (2022); Naqvi et al. (2023)
4	Firm Size	Natural Log	Ln (Total Assets)	Arifin & Wardhani (2021); Bose et al. (2022)
5	ROA	Ratio	Net Income / Total Assets	Arifin & Wardhani (2021); Bose et al. (2022)
6	LEV	Ratio	Total Liabilities / Total Assets	Batten et al. (2021); Bose et al. (2022)

Lending; SIZE, ROA, and LEV represent the control variables; μ_i captures firm-specific fixed effects; and ε_{it} represents the error term.

Robustness Test

In order to examine the strength of the empirical results, other types of estimation using panel data approach have been performed. These include the comparison of the results of the Fixed Effect Model (FEM) used in the analysis as the best estimation model according to Chow and Hausman test against the results of the Random Effect Model (REM) and the Pooled Ordinary Least Squares (Pooled OLS).

Robustness test involves the examination of whether or not the regression coefficients stay the same through the changes in model specification. The result is said to be robust if there is consistency in the direction, size, and level of statistical significance of the regression coefficients regardless of the method of estimation used.

This shows that the coefficients of Internal Audit Quality, Green Lending, and their interaction terms (Internal Audit Quality x Green Lending) stay positive and are still statistically significant even when other alternative approaches of estimation are used. Although there might be some variation in coefficients' values, the conclusions stay the same. It means that the empirical outcomes are robust regardless of the estimation approach for the panel data.

It is crucial to draw a distinction between robustness testing and diagnostics. Multicollinearity, heteroskedasticity, and autocorrelation have been analyzed separately by applying the Variance Inflation Factor (VIF), the Breusch-Pagan test, and the Durbin-Watson statistic, respectively. This proves that the regression model meets the necessary econometric assumptions.

Ethical Approval

The data used in the study was public, secondary data, hence there was no involvement of human subjects in the research. Nevertheless, ethical considerations were considered through citing of all the data sources used in the research, data transparency and maintaining academic integrity. There was no manipulation of any financial data; the study was purely academic.

Result and Discussion

Panel data estimations were used to investigate the impact of internal audit quality and green lending on low-carbon environmental performance (LCEP). Appropriate estimation models were selected using the Chow and Hausman tests.

According to the findings from the Chow test, the cross-section chi-square probability value equals 0.0000 ($p < 0.05$), meaning that the FEM is preferred to the CEM. Moreover, according to the Hausman test, the probability value equals 0.0123 ($p < 0.05$), which means that FEM is preferable to REM. Thus, all hypotheses in the present study were tested using the Fixed Effect Model.

The regression analysis indicates that Internal Audit Quality (IAQ) positively and significantly impacts Low-Carbon Environmental Performance ($\beta = 0.367$, $p < 0.01$) (Table 2). Therefore, the findings show that the enhancement of the quality of internal auditing activities improves environmental governance and internal controls, thus leading to efficient sustainability management. As a consequence, banks with high Internal Audit Quality can implement efficient environmental management measures to facilitate low-carbon development.

In addition, Green Lending (GL) positively and significantly affects Low-Carbon Environmental Performance ($\beta = 0.298$, p

< 0.01). These results reveal that banks using a higher share of financial resources to support environmentally sustainable projects have better environmental performance results. Green lending provides the opportunity for banks to invest in renewable energy, energy-efficient technologies and environment-friendly projects, which helps them participate in the country's low-carbon development.

At the same time, the interaction between Internal Audit Quality and Green Lending (IAQ $\times$ GL) is positive and significant ($\beta = 0.184$, $p < 0.01$). This result confirms the hypothesis on moderation and shows that the improvement of the quality of internal auditing leads to an increase in the positive influence of green lending on Low-Carbon Environmental Performance.

The interaction term between IAQ and GL is positive and statistically significant ($\beta = 0.184$; $p = 0.0061$), indicating that IAQ strengthens the positive effect of Green Lending on LCEP. Thus, H_3 is supported. This finding suggests that the effectiveness of green lending in improving low-carbon environmental performance is greater when banks have stronger internal audit quality.

For the control variables, Firm Size has a positive and significant effect on LCEP ($\beta = 0.018$; $p = 0.0108$), while ROA also has a positive and significant effect ($\beta = 0.426$; $p = 0.0216$). In contrast, Leverage has a negative and significant effect on LCEP ($\beta = -0.031$; $p = 0.0278$). The model reports an R-squared of 0.612 and an adjusted R-squared of 0.587, indicating that approximately 58.7% of the variation in LCEP is explained by the variables included in the model. The overall

Table 2. Panel Regression Results

Variable	Coefficient	Std Error	t-statistic	Prob.
Constant	0.214	0.016	13.375	0.0006
Internal Audit Quality (IAQ)	0.367	0.089	4.123	0.0001
Green Lending (GL)	0.298	0.074	4.027	0.0002
IAQ X GL	0.184	0.066	2.781	0.0061
Firm Size (SIZE)	0.018	0.007	2.571	0.0108
Return on Assets (ROA)	0.426	0.184	2.315	0.0216
Leverage (LEV)	-0.031	0.014	-2.214	0.0278

Source: Processed Secondary data Using Eviews (2025)

Table 3. Model Statistics

R-Squared	Adj R-Squared	F-statistic	Prob
0.612	0.587	24.315	0.00000
235 Data Observations	47 cross sections	banks 2020-2024 period	

Source: Processed Secondary data Using Eviews (2025)

Table 4. Robustness Test

Variable	FEM	REM	Pooled OLS
IAQ	0.367	0.351	0.338
GL	0.298	0.286	0.274
IAQ $\times$ GL	0.184	0.176	0.165
SIZE	0.018	0.017	0.016
ROA	0.426	0.411	0.398
LEV	-0.031	-0.029	-0.027

Notes: FEM = Fixed Effect Model; REM = Random Effect Model; Pooled OLS = Pooled Ordinary Least Squares. Values represent regression coefficients.

Source: Processed Secondary data Using Eviews (2025)

model is statistically significant (F-statistic = 24.315; $p < 0.001$) (Table 3). The regression equation is found to be statistically significant due to the p-value of F-statistic which is 0.0000 ($p < 0.01$). This implies that Internal Audit Quality, Green Lending and the interaction between the two variables help in explaining the differences in the dependent variable, that is, Low-Carbon Environmental Performance.

The Adjusted R^2 value of 0.587 means that about 58.7% of the differences in the Low-Carbon Environmental Performance can be explained by the independent variables in the model whereas the rest of the 41.3% is contributed by other variables which were not included in this study.

Thus, the results of the study show that Internal Audit Quality and Green Lending are equally important in improving environmental performance of banks. Additionally, it was found that Internal Audit Quality helps in increasing the contribution of Green Lending towards the achievement of low-carbon environmental goals.

Table 4 presents the robustness test results using three alternative panel-data estimation approaches: the Fixed Effect Model (FEM), Random Effect Model (REM), and Pooled Ordinary Least Squares (Pooled OLS). The purpose of this analysis is to assess whether the main findings remain consistent when different estimation methods are applied.

The results show that the coefficient of Internal Audit Quality (IAQ) remains positive across all three estimation methods. The coefficient is 0.367 under FEM, 0.351 under REM, and 0.338 under Pooled OLS. Similarly, Green Lending (GL) maintains a positive coefficient across the three models, with values of 0.298, 0.286, and 0.274, respectively. These results indicate that the positive relationship between IAQ, GL, and Low-Carbon Environmental Performance (LCEP) is not substantially affected by the choice of estimation method.

The interaction term between IAQ and GL also remains positive across all specifications, with coefficients of 0.184 for FEM, 0.176 for REM, and 0.165 for Pooled OLS. This consistency supports the finding that the interaction between Internal Audit Quality and Green Lending is positively associated with LCEP. Thus, the moderating relationship identified in the main FEM analysis remains stable under alternative estimation methods.

The control variables also show relatively consistent coefficient directions across the three models. Firm Size (SIZE) has positive coefficients of 0.018, 0.017, and 0.016, while ROA has positive coefficients of 0.426, 0.411, and 0.398 under FEM, REM, and Pooled OLS, respectively. In contrast, Leverage (LEV) remains negative, with coefficients of -0.031, -0.029, and -0.027. Therefore, the direction of the relationships between the control variables and LCEP is also stable across the alternative specifications.

Overall, the robustness results indicate that the main empirical conclusions are stable across FEM, REM, and Pooled OLS specifications. Although the magnitude of the coefficients varies slightly across the estimation methods, the direction of the relationships remains unchanged. These findings strengthen the reliability of the main regression results and suggest that the observed relationships are not driven solely by the choice of panel-data estimation technique.

Table 5 provides the descriptive statistics for all variables

Table 5. Descriptive Analysis

Variable	Mean	Median	Maximum	Minimum	Std Dev.
LCEP	0.684	0.691	0.921	0.402	0.118
IAQ	0.712	0.725	0.950	0.430	0.105
GL	0.287	0.274	0.645	0.081	0.129
SIZE	31.547	31.421	34.102	28.764	1.254
ROA	0.021	0.019	0.054	-0.008	0.013
LEV	0.842	0.851	0.932	0.654	0.067

Source: Processed Secondary data Using Eviews (2025)

included in this research, which include the mean, median, maximum, minimum, and standard deviation of the variable using 235 firm-year data for 47 Indonesian listed commercial banks in the 2020-2024 period. The results reveal that the mean value of LCEP is 0.684 (SD = 0.118), which reflects a moderate level of environmental performance in the selected banks. IAQ has the highest mean value of 0.712 (SD = 0.105), revealing that the selected banks have relatively high-quality internal audit and governance systems. On the other hand, GL has a lower mean of 0.287 (SD = 0.129), meaning that environmentally sustainable lending is still a relatively small share of total lending activity, with variations across banks. As for the control variables, SIZE has an average value of 31.547, meaning that the sample largely comprises of medium to large-sized commercial banks, while the average ROA of 0.021 shows profitability in the observation period. The average LEV of 0.842 suggests that there is a high dependence on liabilities in the capital structure of the banking industry. In summary, the results from the descriptive statistics imply that while IAQ is relatively well developed in Indonesian listed commercial banks, there is much room for growth in terms of Green Lending and Low-Carbon Environmental Performance.

The findings of the current study suggest that Internal Audit Quality and Green Lending are essential factors to increase Low-Carbon Environmental Performance (LCEP) in commercial banks listed in Indonesia. The results suggest that Internal Audit Quality has a significant positive impact on LCEP, Green Lending positively impacts LCEP, and Internal Audit Quality positively moderates the relationship between Green Lending and LCEP. The results suggest that governance practices and sustainable financing are mutually supportive strategies instead of two separate strategies in the shift towards a low-carbon economy in the banking industry.

The positive impact of Internal Audit Quality on Low-Carbon Environmental Performance is consistent with the predictions of Agency Theory, according to which proper monitoring devices are used to minimize information asymmetry and resolve agency problems between management and stakeholders (Jensen & Meckling, 1976). Well-developed internal auditing facilitates effective governance by enhancing internal controls, assessing environmental risks, and complying with the requirements of sustainability regulations. In this way, internal audit plays an important role in promoting environmental performance through effective monitoring and assurance.

The positive coefficient of firm size suggests that larger banks may possess greater organizational and financial capacity to implement environmental governance and sustainable finance initiatives. The positive association between ROA and LCEP may indicate that more profitable banks have greater resources to invest in sustainability. Conversely, the negative coefficient of leverage suggests that greater financial obligations may constrain banks' capacity to prioritize environmental initiatives.

These findings also support the theory of Stakeholder Theory (Freeman, 1984), according to which businesses should be able to take into account the demands of various stakeholders, such as regulators, shareholders, customers, and the wider community. Growing societal interest in climate change and sustainable financing has prompted banks to develop their governance tools, which would help them be

environmentally responsible. The role of Internal Audit Quality comes into play here because it helps build credibility in sustainability reporting, assesses environmental risk management, and ensures that sustainability promises are fulfilled. It is also noteworthy that these findings are in line with the Global Internal Audit Standards (Institute of Internal Auditors, 2024), according to which internal audit is a strategic governance function that supports corporate sustainability and value creation. Moreover, these findings confirm the results of the studies carried out by Christ et al. (2021), Eulerich et al. (2022), and Drogalas et al. (2023).

These findings reveal that Green Lending positively influences Low-Carbon Environmental Performance. This suggests that green finance is a crucial tool that allows banks to engage in environment-friendly investments by funding renewable energy, energy-efficient systems, sustainable infrastructure, and environment-friendly business operations. This approach helps banks reduce the carbon emissions in the country by channeling funds to environmentally safe projects and, thus, contributes to the accomplishment of low-carbon development objectives in the nation. These research findings support the works of earlier researchers such as Campiglio (2016), Bose et al. (2022), Naqvi et al. (2023), Hussain et al. (2024), and Jahanger et al. (2024).

From the perspective of Institutional Theory (DiMaggio & Powell, 1983), the positive impact of Green Lending stems from the increasing pressures of institutions that compel financial institutions to follow sustainable finance policies. The Indonesian Sustainable Finance Regulations formulated by the Financial Services Authority (OJK), especially the second phase of Sustainable Finance Roadmap (2021-2025), have increased the institutional pressure in terms of risk management towards environmental protection as well as green finance. As such, banks that show more dedication towards the policy of Green Lending exhibit better Low-Carbon Environmental Performance.

One of the key insights of this study concerns the important moderating effect of Internal Audit Quality. The positive interaction between Internal Audit Quality and Green Lending shows that an efficient internal audit process enhances the contribution of environmentally sustainable financing to the environmental performance. This finding means that Green Lending in itself is unlikely to lead to the best possible environmental outcomes without adequate governance structures that will ensure proper implementation, monitoring, and evaluation of environmentally sustainable financing operations.

This moderating effect could be justified by the strategic position of internal auditors when it comes to assessing environmental risks, checking the compliance with the regulations concerning sustainable finance, monitoring the implementation of green financing policies, and strengthening internal control processes. The high quality of the internal audit process eliminates any weaknesses in governance and increases organizational accountability, which in turn allows Green Lending programs to make larger contributions in the field of environmental performance. The current study extends existing governance literature by showing that internal audit functions are important not only for organizational control but also for sustainable finance.

This research is also significant for sustainable finance and corporate governance theories. Most of the previous researchers have studied Internal Audit Quality and Green Lending in isolation to explain the performance in the environment and finances. However, the integration of both variables into one framework shows that governance quality plays an important role as organizational capacity, which enhances the environmental impact of sustainable finance. Therefore, the results contribute to Agency Theory,

Stakeholder Theory, and Institutional Theory because they reveal how governance instruments and sustainable finance affect the Low-Carbon Environmental Performance in emerging market banks.

The results are also important for regulators, policymakers, and practitioners in banking. From the perspective of regulators, especially the Financial Services Authority (OJK), it can be seen that there is a need to regulate sustainable finance and encourage banks to improve their internal governance systems. Management of banks must enhance the quality of the internal audit function through the adoption of risk-based auditing practices, ESG assurance activities, sustainability monitoring, and cooperation between internal auditors and audit committees. At the same time, banks must increase the scope of Green Lending in order to finance environmentally sustainable projects and achieve a low-carbon economy in Indonesia.

Finally, this study makes a valuable contribution to the body of knowledge of sustainable banking through an empirical investigation of Indonesian listed commercial banks for the period of 2020–2024. In contrast to earlier studies, which have examined mostly the impact of the independent variable Internal Audit Quality or Green Lending, this study shows that the quality of Internal Audit is used as a governance tool which enhances the impact of Green Lending on achieving Low-Carbon Environmental Performance. The above approach helps to fill the gap in the existing literature on sustainable finance, which deals with the process of converting environment-friendly investments into environmental performance.

Interpretation of Key Findings

The results obtained from this research reveal that Internal Audit Quality, Green Lending, and their interaction play an important role in determining Low-Carbon Environmental Performance (LCEP) in Indonesia listed commercial banks. The positive impact of Internal Audit Quality implies that banks, which have better internal audit quality, perform better in the environmental aspect. The better internal audit quality improves the governance of banks by strengthening internal control, environmental risk management, regulation compliance, and accountability in environmental decision making. As a result, the better internal audit function is one of the key aspects of governance, which ensures the success of low-carbon policies in banking institutions.

Additionally, the results also reveal that Green Lending has a positive and significant impact on LCEP. In particular, banks that invest a higher share of finance in environmentally sustainable activities, including renewable energy, energy efficiency, and other green projects, are more likely to reduce carbon emission and promote sustainable economic development. It can be concluded that the Green Lending is not only a financial tool but also a strategic tool for the transition of banks into a low-carbon economy.

Equally important is the statistically significant positive interaction effect between Internal Audit Quality and Green Lending. The result suggests that Internal Audit Quality reinforces the efficiency of Green Lending in enhancing Low-Carbon Environmental Performance. It can be interpreted that governance quality, along with the existence of internal control and auditing process, contributes to more environmentally sustainable sustainable finance activities. Thus, the research concludes that governance quality and sustainable financing are interrelated organizational strengths that go hand-in-hand in contrast to being separate approaches. The combination of these two approaches will help Indonesian listed commercial banks to improve environmental accountability and sustainability performance.

Comparison with Previous Studies

The results of this study are consistent with other studies that focused on the role of good governance and sustainable

finance in enhancing the environmental performance of organizations. The positive relationship between Internal Audit Quality and Low-Carbon Environmental Performance is consistent with other empirical studies by Abbott et al. (2016), Christ et al. (2021), Eulerich et al. (2022), and Drogalas et al. (2023), which have found out that having high quality internal audit processes leads to improved internal control systems, increased organizational accountability, risk management, and good governance practices. In light of the above mentioned points, the current paper has also found out that efficient internal auditing process helps organizations achieve environmental sustainability through enhancing banks' capability of monitoring their low-carbon operations.

Another positive effect of Green Lending is also supported by previous researches which have shown the importance of sustainable finance for environmental sustainability. Previous research by Campiglio (2016), Bose et al. (2022), G. Zhou et al. (2022), Naqvi et al. (2023), Hussain et al. (2024), and Jahanger et al. (2024) concluded that green financing increases investment in renewable energy sources, energy efficiency, and environmentally-friendly business operations and results in carbon emissions reduction and sustainable development. The current study confirms this fact by revealing the existence of a positive relationship between Green Lending and Low-Carbon Environmental Performance among Indonesian listed commercial banks.

An innovative aspect of this study is analyzing the role of the quality of the internal audit function on the influence of Green Lending on Low-Carbon Environmental Performance. Unlike previous studies that usually considered these variables separately, this research reveals that internal audit quality can increase the effectiveness of Green Lending on Low-Carbon Environmental Performance. It means that the effectiveness of sustainable financing increases when it is accompanied by good governance, internal control, and monitoring. Additionally, whereas most previous studies examined financial performance, firm value, and ESG disclosure as dependent variables, this research analyzes Low-Carbon Environmental Performance of Indonesian listed commercial banks as the dependent variable. Hence, this study makes an innovative contribution to the literature on sustainable financing and corporate governance.

Limitations and Cautions

There are various limitations to this study that must be kept in mind while interpreting the results. First of all, there is an exclusive use of secondary data from annual reports, sustainability reports, and other corporate discourses of Indonesian listed commercial banks. Hence, the measurement of the variables Internal Audit Quality, Green Lending, and Low-Carbon Environmental Performance is dependent on the extent of corporate disclosures in the concerned reports.

Second, the variable Internal Audit Quality is measured using a disclosure index, measuring the presence of governance and internal audit practices, and not their quality and impact on corporate governance and sustainable development practices. While it is true that disclosure-based measurements have been extensively used in corporate governance research studies, such measurements may not be an accurate reflection of the quality of internal audit process and its role in organizational decision-making.

Finally, this study uses data only from 47 Indonesian listed commercial banks during the observation period of 2020–2024. As a result, the results obtained from this study may not be fully generalizable to other financial organizations outside of Indonesia or other listed/non-listed commercial banks and firms in other industries or countries.

The last limitation related to endogeneity and reverse causation problems. Banks with good Low-Carbon

Environmental Performance will be more prone to have good Internal Audit Quality and will promote the Green Lending activities, rather than the opposite. Even though the use of advanced econometric methods such as the Generalized Method of Moments (GMM) and instrumental variable (IV) estimation would solve the problem, it was not possible in this study as a small sample of 47 listed commercial banks is used.

Further research should use larger cross-country data sets and apply more sophisticated econometric methods to address the endogeneity problem, due to the relatively small sample size in the cross-sectional design used in the present paper. Further research could include the use of other governance factors in the analysis such as the audit committee effectiveness, board sustainability committees, ESG assurance and enterprise risk management.

Recommendations for Future Research

Future research can take the form of an expansion of the current research through inclusion of other governance, sustainability, and financial variables which may shed some more light on the variations of Low-Carbon Environmental Performance. Some of the variables that may be considered in future studies include audit committee quality, boards' sustainability committees, enterprise risk management, ESG assurance, digital governance, environmental risk management, and climate-related financial disclosures.

Future research may involve extension of the time periods and sample sizes as well as use of cross-country data. Comparative analysis between countries will help explore the impact of different institutional contexts, sustainable finance regulations, and corporate governance systems on the relationship between Internal Audit Quality, Green Lending, and Low-Carbon Environmental Performance.

Further, it is suggested that future researches consider adopting more sophisticated research designs and methodologies. Using the dynamic panel estimation approach like the Generalized Method of Moments (GMM) or quasi-experimental methods can solve possible endogeneity problems and help with causal inferences. Using mixed methods which include the use of interviews or case studies along with the quantitative analysis can offer an insight into how internal auditors, management and regulators implement sustainable finance and environmental governance in the banks.

Lastly, future researches can improve the measurement of Internal Audit Quality and Low-Carbon Environmental Performance by considering a set of more comprehensive measures which will not only include the practices of disclosure but also their effectiveness in terms of environmental performance.

Practical Implications

The conclusions reached from this research study offer several practical implications to regulators, banks, and policymakers. Regulators, especially the Financial Services Authority (OJK), need to pay attention to the regulatory framework surrounding sustainable finance, environmental governance, and ESG reporting. Improvement of the reporting framework and giving better guidelines as to the integration of governance and sustainable finance will push the banks to become more transparent and accountable to the environment.

To the banking institutions, the study results indicate that Internal Audit Quality needs to be seen as a strategy of governance rather than just a compliance issue. The banking institutions need to strengthen their risk-based internal auditing and include environmental and climate risk in the planning of the audits, as well as improve their ESG assurance. They also need to improve coordination among the internal auditors, the audit committees, and senior management. While

doing so, the banking institutions also need to expand Green Lending portfolios by funding renewable energy and energy efficiency activities.

From a policy standpoint, the results provide justification for the further deployment of the Sustainable Finance Roadmap and the national low-carbon development program in Indonesia. Policy makers should advocate more closely intertwined corporate governance practices and sustainable finance initiatives by offering incentives to those banks which have shown good internal corporate governance practices and increased dedication to environmental finance. The strengthening of synergy between the Internal Audit Quality and Green Lending practices is supposed to enhance the environmental performance at the same time contributing to the creation of sustainable low-carbon economy in Indonesia.

The findings also becomes clear from the research results that banks need to pay more attention to their ESG assurance practices and incorporate the Internal Audit Quality into Green Lending policies (Isack & Aschauer, 2025).

Conclusion

This research explores the effects of Internal Audit Quality and Green Lending on Low-Carbon Environmental Performance (LCEP) of Indonesian listed commercial banks over the period 2020–2024. Based on the results, it is found that both Internal Audit Quality and Green Lending have a positive and significant influence on Low-Carbon Environmental Performance. In addition to that, it is found that there is a significant interaction between Internal Audit Quality and Green Lending, implying that high quality internal auditing helps to make Green Lending more effective in improving environmental performance. Thus, all hypotheses were supported by the empirical results. It means that H1 is confirmed since Internal Audit Quality positively affects Low-Carbon Environmental Performance, H2 is confirmed because of Green Lending positively influences Low-Carbon Environmental Performance, and H3 indicates the positive moderation of Internal Audit Quality on the relation between Green Lending and Low-Carbon Environmental Performance.

The study contributes to the body of knowledge in sustainable finance and corporate governance by showing that Internal Audit Quality and Green Lending are complementary organizational resources rather than independent organizational mechanisms. Unlike previous studies which have focused on either governance quality or sustainable finance, this study contributes to the literature by providing empirical evidence that effective internal audits are capable of increasing the environmental benefits of Green Lending. The theory application of Agency Theory, Stakeholder Theory, and Institutional Theory is also extended through this study since it explains how governance mechanisms can increase the

success of sustainable finance to create better environmental performance of emerging-market banking organizations.

In practice, this study shows that banking organizations should develop their Internal Audit Quality by improving risk-based audit, internal controls, ESG assurance, and sustainability monitoring in addition to increasing their Green Lending portfolio to facilitate environmentally sustainable financing activities. For regulators, especially the Financial Services Authority (OJK), the study contributes empirically to the improvement of sustainable finance policies and integration of governance practices with environmental finance in meeting Indonesia's low-carbon development goals.

While this research offers valuable empirical data, several drawbacks are present. In particular, this work uses only the Indonesian listed commercial banks for the period from 2020 to 2024 and uses disclosure-based measurement of Internal Audit Quality and Low-Carbon Environmental Performance. Thus, the results obtained have to be interpreted within this specific institutional environment. Future studies are recommended to expand their analysis to other samples from different countries and industries and also include other governance and ESG factors while using more sophisticated econometric models, for example, dynamic panel regression and instrumental variables model.

Author contributions

Author 1 conceived the research idea, designed the methodology, conducted the data analysis, interpreted the results, and prepared the original manuscript. Author 2 supervised the research, reviewed and edited the manuscript, validated the findings, and approved the final version of the manuscript. All authors have read and approved the final manuscript.

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