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Sustainability practices and cost of capital: An empirical study of agricultural enterprises across global markets

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Abstract: This study explores how corporate sustainability and Environmental, Social, and Governance (ESG) performance are linked to the cost of capital in the financial markets of agricultural enterprises around the world. For the period from 2019 to 2024, a sample set of more than 1,200 agricultural enterprises from North America, Europe, and Asia-Pacific is examined using multiple regression to explore the role of ESG factors in shaping a company's WACC. It was observed that for each additional point in the ESG composite score, WACC decreases by 0.035 percentage points. The impact varies by region, being strongest in European agricultural enterprises, somewhat less in North America, and mildest in Asia-Pacific. Based on the analysis, environmental considerations are found to significantly reduce WACC more than other factors. These data indicate that incorporating sustainability helps companies reduce costs and increase their value, confirming to managers and investors that sustainability can be a key strategy in agricultural enterprises. The paper concludes by outlining policies for change and proposing new research topics at the intersection of sustainability and corporate finance in agricultural enterprises.

Keywords: *Agricultural enterprises, Corporate sustainability, Cost of capital, Empirical analysis, ESG performance, Financial performance, Global markets, Weighted average cost of Capital.*

1. Introduction

In recent years, the global business world has seen major changes because more emphasis is being put on sustainability in agricultural enterprises. From a side issue, corporate sustainability, which includes caring for the environment, social concerns, and robust rules, has grown to play a major role in running companies of agricultural enterprises. More pressure comes from the public, rules set by regulators, and demands from investors for honesty and right behavior [1]. Following sustainability in a company's approach to decision-making is both the right thing to do and key to improving financial results and addressing risks in agricultural enterprises.

The core of the change is Environmental, Social, and Governance (ESG) criteria, which help turn corporate sustainability into actions that can be measured in agricultural enterprises. Environmental factors consider the company's effect on the environment and actions to stop climate change, while social criteria look at workforce policies, community support, and human rights issues; governance concerns the way a company is led and structured. Because of these dimensions, stakeholders can judge a business's sustainability and its ability to last over the long run [2].

At the same time, the marketplace of agricultural enterprises has seen a change in which traditional ways of assessing business risk and return are being adjusted to reflect ESG factors in financial models. More and more, it is shown that agricultural enterprises that care about sustainability achieve higher operating performance, better brand recognition, and face less risk from law and lawsuits. For this reason, investors have come to see that sustainability performance signals whether a company can

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maintain stability in earnings, which is why sustainability finance is now gaining widespread recognition [3].

WACC or the Weighted Average Cost of Capital, is one of the main financial metrics affected by sustainability. WACC represents the average rate a company pays for its capital, based on its composition of debt and equity. In the corporate finance of agricultural enterprises, it helps guide investment decisions, asset evaluation, and capital allocation. A lower WACC indicates that companies pay less for capital, which facilitates expansion, improvement, competitiveness, and increased success [4].

Several theories show how sustainability practices relate to the cost of obtaining capital for corporations in agricultural enterprises. Because ESG leaders can easily adapt to new regulations, manage their reputation, and handle stakeholder issues, they are generally considered to have fewer operational and financial risks. This risk mitigation reduces the risk premiums demanded by equity and debt holders. Second, sustainable firms often benefit from enhanced access to capital markets, including green bonds and sustainability-linked loans, which provide cheaper funding options. Third, proactive sustainability initiatives signal management quality and long-term orientation, thereby increasing investor confidence and lowering the cost of equity. Fourth, regulatory environments in many regions increasingly incentivize sustainable practices through tax benefits, subsidies, or penalties, which indirectly affect capital costs [5].

Despite the growing body of literature on ESG investing and sustainable finance, the empirical relationship between corporate sustainability and the cost of capital remains a contested domain. Prior studies have reported mixed results, with some identifying a negative relationship indicating lower financing costs for sustainable firms, while others find insignificant or even positive associations. Such inconsistencies could be explained by the different approaches used, the properties of the samples, the range of industries, and regional settings. Most of the studies to date have been conducted on mature markets of agricultural enterprises like the United States and Europe, overlooking emerging economies and comparisons among different regions [6].

Since the financial markets of agricultural enterprises differ in different areas globally, it is necessary to analyze several markets to see how corporate sustainability changes the cost of capital for companies in various countries. Because developed markets have strict rules, active investors, and clearer disclosure, the role of ESG factors can be strengthened on the cost of raising capital. However, the finance and enforcement sectors in emerging markets are still developing, and the priorities of these investors also play a significant role, so their efforts to be sustainable are also quite different in comparison [7].

The research adds to the field by empirically investigating how sustainability relates to the cost of capital of agricultural enterprises in major regions: North America, Europe, and Asia-Pacific. With a dataset including over 1,200 firms from listed companies between 2019 and 2024, the research incorporates sustainability ratings provided by leading agencies into financial data to analyze the effect of ESG performance on WACC of agricultural enterprises. Applying fixed effects and instrumental variables, the analysis removes bias from both endogeneity and omitted variables.

The specific objectives of this research are threefold: (1) to quantify the overall effect of ESG performance on the cost of capital in agricultural enterprises; (2) to explore regional differences in this relationship across developed and emerging markets; and (3) to identify which ESG dimensions (environmental, social, or governance) most strongly influence capital costs in agricultural enterprises. By addressing these questions, the study provides nuanced insights into how sustainability integration shapes the financial risk and cost structures of agricultural enterprises globally.

The implications of this research are significant for multiple stakeholders. Corporate executives can leverage the findings to justify investments in sustainability initiatives by highlighting potential financial benefits in terms of reduced capital costs of agricultural enterprises. Financial institutions and investors use actual data to correct their models and better monitor risks when using ESG factors. The

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findings can help policymakers and regulators establish rules that assist corporate sustainability and earn positive results from capital use.

1.1. Background

1.1.1. Emergence of Corporate Sustainability of Agricultural Enterprises in Global Business

Corporate sustainability has gradually developed from an unusual concern into a central business issue for companies worldwide. Society's increased awareness of environmental issues, unequal treatment of people, and government problems have led to higher expectations from organizations. More and more, companies are expected to focus on profit while also demonstrating concern for the environment and the communities near their facilities.

The move toward sustainability has been advanced by the adoption of the SDGs, the Paris Agreement, and many national policies. As a result, agriculture companies are now integrating environmental aspects, fairness to all, and good governance into their business approach, aiming to deliver long-term benefits to their shareholders as well as society [8].

1.1.2. Defining Corporate Sustainability: The ESG Paradigm

Most often, corporate sustainability is implemented using Environmental, Social, and Governance (ESG) criteria. They create a comprehensive framework for measuring a firm's sustainability.

Environmental (E): In this dimension, companies are examined for their effects on natural resources, carbon emissions, waste control, air and water pollution, and their efforts to reduce climate change. It reveals how organizations handle their use of natural resources and follow environmental regulations.

Social (S): The social aspect examines how a company interacts with its employees, customers, suppliers, and the community. Important topics include labor practices, diversity and inclusion, human rights, community outreach, and product safety.

Governance (G): It focuses on issues such as the structure and skills of corporate leadership, transparency, the diversity of people on boards, how much influence shareholders have, and ethical business actions. When governance is done well, organizations manage risks and make better decisions more effectively [9].

The framework's recognition stems from its ability to measure sustainability ideas and convert them into actions that investors can review and that companies can report.

1.1.3. The Rise of Sustainable Finance of Agricultural Enterprises and Its Market Impact

Since ESG factors are being used more in investments, sustainable finance plays an important role in the global capital markets of agricultural enterprises. Investors today admit that sustainability risks, which include climate change and social disputes, can actually damage a company's earnings and overall value. According to GSIA, more money than ever was invested sustainably worldwide, with over one-third of all professionally managed assets being guided by sustainability in 2022.

Various green bonds, loans linked to sustainability goals, and mutual funds and ETFs with an ESG approach have appeared, giving both agriculture companies and investors ways to achieve their financial and sustainability objectives. Consequently, markets are now pressuring companies to report on ESG issues clearly and publicly, and more individuals are analyzing firms' environmental impact [10].

1.1.4. The Cost of Capital: A Critical Financial Metric

In corporate finance, the cost of capital refers to what investors in debt and equity need to be paid to compensate for the risks they undertake when investing in a company. The weighted average cost of capital (WACC) combines these costs by weighting them according to the firm's capital structure.

This also helps businesses because it reduces their financing costs, provides better investment opportunities, and adds value to their shares. Higher interest rates associated with capital can restrain company growth and make the company appear risky to investors [11].

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1.1.5. Linking Corporate Sustainability and Cost of Capital of Agricultural Enterprises

Many are now aware that there is a link between corporate sustainability and the cost of raising capital, yet the link is considered complicated. Superior ESG performance by a company might lower its costs of obtaining funds from various sources:

- Risk Reduction: Effective sustainability practices mitigate operational, regulatory, and reputational risks, decreasing risk premiums demanded by investors and creditors [12].
- Improved Access to Capital: Agriculture firms with strong ESG credentials often attract a broader and more diversified investor base, including those dedicated to sustainable investments.
- Signaling Effect: Transparent sustainability disclosures signal management quality and long-term orientation, boosting investor confidence.
- Regulatory Incentives: Policies encouraging sustainable practices can lower the financing costs of agricultural enterprises through tax benefits, subsidies, or preferential lending terms [13].

1.1.6. Regional Differences and Market Maturity

For different countries, the way the cost of capital of agricultural enterprises reacts to corporate sustainability depends on variations in regulations, the wishes of investors, openness in the market, and culture. Because of tough regulations and lots of investor involvement, European regions have often developed ESG integration in agricultural enterprises. In North America, sustainability is increasing but does not happen in the same way everywhere, whereas Asia-Pacific markets range from advanced economies using traditional ESG values to developing areas that are less regulated.

This difference between regions demonstrates the importance of studying how institutional settings impact a company's finances related to sustainability [14, 15].

1.2. Theoretical Frameworks

Many theories explain the relationship between corporate sustainability and cost of capital:

- Risk Mitigation Theory: According to Risk Mitigation Theory, ESG helps firms solve their environmental challenges, resolve social conflicts, and overcome governance problems. A lower risk in the company reduces the required rate of return for investors and lenders, which lowers WACC [16].
- Signaling Theory**:** In Signaling Theory, the disclosure of ESG work by firms explains their strong management and survival over time, increases trust among investors, and helps reduce gaps in information. A clearer and more responsible approach can save a company money in both equity and debt [17, 18].
- Stakeholder Theory: Practicing sustainability leads to better stakeholder relationships, which helps businesses improve their operations and lowers the risks they face [19, 20].
- Institutional Theory: According to Institutional Theory, institutions such as investors and regulators are helping to improve how firms handle sustainability by setting ESG standards. Following regulated rules can help avoid additional costs in capital expenditure [21, 22].

They help us understand that strong ESG practices by a firm may result in a reduction of capital expenses, but the extent of this effect depends on the circumstances [23].

1.3. Research Gap and Contributions

Although previous studies have examined aspects of sustainability and determining capital costs, much remains missing:

- Most empirical work focuses on single markets, limiting understanding of global dynamics.
- Limited research disentangles the relative impact of environmental, social, and governance factors on financing costs.

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- Few studies employ advanced econometric methods to address endogeneity and measurement challenges in ESG data.
- This document addresses these gaps with the help of
- The analysis uses data from North America, Europe and the Asia-Pacific regions.
- Analyzing ESG separately to find where differences between companies appear.
- The use of complicated statistical techniques to draw conclusions about causality and raise reliability.

1.4. Significance of the Study

Realizing how corporate sustainability changes the cost of capital in agricultural enterprises is very important. For businesses, the agricultural industry environment impacts where resources are spent and how they communicate with shareholders [24]. Investors can manage their portfolio risks and improve their profits with it. For those in charge of regulation, it shows the way to plan for sustainable economic growth. At its core, this research builds understanding at the green finance interface, aiding efforts to make the economy more stable and ethically responsible.

2. Materials and Methods

2.1. Research Design and Approach

A quantitative approach is used in this study to observe the effects of corporate sustainability on the final cost of capital in large financial markets of agricultural enterprises worldwide [25]. Thanks to data spanning six years, from 2019 through 2024, the study explores how environmental, social, and governance (ESG) performance impacts a firm's cost of borrowing over the long term. The panel design allows for the management of unseen factors among different firms and considers time effects, which supports reliable conclusions about causal effects [26].

Econometric modeling is used as the research framework, where fixed effects regressions account for unchanging characteristics of firms, and all agricultural firms are affected by common shocks each year. Because reverse causality and missing variables could make the results unreliable, the study uses instrumental variable analysis to determine how sustainability affects the WACC [27].

2.2. Data Collection and Sample Construction

2.2.1. Data Sources

Different high-quality and public sources of data are used to build an accurate dataset with sustainability, financial, and agriculture market information. The study dataset entails a sample of 1,236 agricultural companies in North America, Europe, and the Asia-Pacific. These companies were sampled from among the publicly traded companies in major exchanges such as the NYSE, NASDAQ, Toronto Stock Exchange (TSX), London Stock Exchange (LSE), Euronext, Deutsche Börse, SIX Swiss Exchange, Shanghai Stock Exchange (SSE), Hong Kong Exchange (HKEX), Australian Securities Exchange (ASX), and Tokyo Stock Exchange (TSE).

2.2.1.1. Central features of the Sample

Geographic Distribution: The data is equally distributed among firms located in North America (480), Europe (410), and Asia-Pacific (346).

ESG Rating: Every company has its yearly ESG scores provided by at least one of the three rating companies: MSCI ESG Ratings, Sustainalytics, or Refinitiv ESG, to determine sustainability performance between 2019 and 2024.

Exclusion Criteria: Companies falling under financials and utilities were eliminated since their capital structures are divergent. Also, companies with anomalies in financial reporting, extreme outliers, or missing values were eliminated from the sample.

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ESG Performance Data: The data comes from three leading rating agencies: MSCI ESG Ratings, Sustainalytics, and Refinitiv ESG. To generate an annual report of company sustainability, these companies use a process that relies on firm disclosures, regulatory and media coverage, and reports from third parties. To make scores from different organizations similar, companies' ESG scores are rescaled to 0–100 and averaged to give the main company sustainability rating, plus split ratings for environmental, social, and governance factors [28].

Financial Data: The financial information of an agriculture firm that we use to calculate WACC and other factors is taken from Bloomberg Professional and Thomson Reuters Eikon databases. It means you use information from the balance sheet, income, and cash flow statements such as total assets, total debt, stocks, and equity market capitalization, shares outstanding, interest paid, and profit [29].

Macroeconomic and Market Data: GDP growth, inflation, and yields on bonds issued by governments come from gathering data at the World Bank, International Monetary Fund (IMF), and Organization for Economic Cooperation and Development (OECD). In addition, key figures considering the effectiveness of sustainability laws are pulled from unique data sources focused on worldwide environmental and social regulations [30].

2.2.2. Sample Selection Criteria

To start, all publicly traded agriculture companies from leading exchanges in three geographic regions are included in the initial sample frame:

- North America: Including Agriculture Company in NYSE, NASDAQ, and Toronto Stock Exchange (TSX).
- Europe: Including agricultural enterprises in the London Stock Exchange (LSE), Euronext, Deutsche Börse, and SIX Swiss Exchange.
- Asia-Pacific: Including agricultural enterprises in the Shanghai Stock Exchange (SSE), Hong Kong Exchange (HKEX), Australian Securities Exchange (ASX), and Tokyo Stock Exchange (TSE).

Below is the Selection criteria:

- Firms must have available ESG scores from at least one of the aforementioned rating agencies for each year between 2019 and 2024.
- Complete financial data necessary for WACC computation must be available for all years in the sample period.
- Financial firms and utilities are excluded due to their distinct capital structures and regulatory environments, which could bias results.
- Firms exhibiting significant anomalies in financial reporting, such as extreme outliers in leverage or profitability, or those with missing data, are removed.
- Firms delisted or undergoing mergers during the sample period are excluded to maintain consistency.

According to these standards, the final dataset includes 1,236 firms, with 480 in North America, 410 in Europe, and 346 in Asia-Pacific.

2.3. Variables and Measurement

2.3.1. Dependent Variable: Weighted Average Cost of Capital (WACC)

The key factor we explore in this analysis is the Weighted Average Cost of Capital (WACC) for the firm, which shows the average cost of both debt and equity funding the company has taken. WACC is calculated annually for each firm using the formula [31]:

$$\mathrm{WACC}i,t = \mathrm{Ei},t/\mathrm{Vi},t \times \mathrm{re},i,t + \mathrm{Di},t/\mathrm{Vi},t \times \mathrm{rd},i,t \times (1 - \mathrm{Tc},i,t)$$

Where:

- Ei,t: The market value of equity for firm iii at time ttt is approximated by multiplying the number of shares outstanding by the closing stock price.

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- Di,t: Book value of total debt for firm iii at time ttt.
- Vi,t: Total value of the firm.
- re,i,t: Cost of equity, estimated using the Capital Asset Pricing Model (CAPM) as:

$$re, i, t = rf + \beta i(rm - rf)$$

Where rf is the risk-free rate (proxied by the yield on government bonds of matching maturity), βi is the firm's beta estimated from the regression of stock returns on market returns over a 60-month window, and rm is the expected market return.

- rd,i,t: Cost of debt, calculated as the ratio of interest expense to total debt.
- Tc,i,t: Firm-specific effective corporate tax rate, sourced from annual financial reports.

2.3.2. Independent Variable: Corporate Sustainability (ESG Scores)

The key independent variable is the corporate sustainability score, operationalized through ESG ratings. Three variants are examined:

- Composite ESG Score: An aggregate measure combining environmental, social, and governance components.
- Environmental (E) Score: Reflects firm initiatives on carbon emissions reduction, pollution control, natural resource management, and climate risk mitigation.
- Social (S) Score: Captures labor standards, diversity and inclusion, human rights practices, and community engagement.
- Governance (G) Score: Measures board independence, audit quality, executive remuneration, and shareholder rights [32].

Scores are standardized to a 0–100 scale and averaged across rating providers to minimize rating agency bias.

2.3.3. Control Variables

To mitigate omitted variable bias and isolate the impact of ESG on WACC, a comprehensive set of control variables is included.

- Firm Size: Natural logarithm of total assets, controlling for economies of scale and resource availability.
- Leverage: Ratio of total debt to total assets, indicating financial risk exposure.
- Profitability: Return on assets (ROA), computed as net income divided by total assets.
- Market-to-Book Ratio: Market capitalization divided by the book value of equity, reflecting growth opportunities and intangible assets.
- Industry Fixed Effects: Dummy variables categorizing firms by Standard Industrial Classification (SIC) codes to control for industry-specific risk factors.
- Year Fixed Effects: Dummy variables for each calendar year to control for macroeconomic cycles, regulatory changes, and global financial shocks.

2.4. Econometric Strategy

2.4.1. Panel Data Regression with Fixed Effects

The baseline empirical model employs a firm-year panel regression with fixed effects to estimate the relationship between ESG performance and WACC [33]:

$$WACCi, t = \beta 0 + \beta 1 ESGi, t + \beta 2 Xi, t + \gamma i + \delta t + \epsilon i, t$$

Where:

- WACCi,t is the dependent variable.
- ESGi,t represents the key independent variable (either composite or sub-scores).
- Xi,t is a vector of control variables.
- γi denotes firm fixed effects, accounting for unobserved, time-invariant firm characteristics.

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- δt denotes year fixed effects.
- ϵi,t is the error term, assumed to be independently and identically distributed.

Fixed effects models control for unobserved heterogeneity, such as management quality or corporate culture, that could bias estimates if omitted.

2.4.2. Addressing Endogeneity: Instrumental Variables

Corporate sustainability investments may be endogenous due to:

- Reverse Causality: Firms with a lower cost of capital might have greater resources to invest in sustainability.
- Omitted Variables**:** Unobserved factors influencing both ESG and WACC.

To address this, the study uses a two-stage least squares (2SLS) instrumental variable approach.

2.4.2.1. Instrument Construction

The instrument is a regional sustainability regulatory intensity index (RSRII)**,** constructed from regulatory databases measuring the strength, enforcement, and scope of sustainability-related policies in each firm's home country and region. The RSRII varies over time and region but is exogenous to individual firm financing decisions.

2.4.2.2. 2SLS Procedure

- First Stage: Regress ESG scores on the RSRII and control variables.

$$ESGi,t = \pi 0 + \pi 1RSRIIr,t + \pi 2Xi,t + \mu i + \tau t + \nu i,t$$

- Second Stage: Use predicted ESG values from the first stage to estimate WACC.

$$WACCi,t = \alpha 0 + \alpha 1ESGi,t + \alpha 2Xi,t + \gamma i + \delta t + \epsilon i,t$$

The relevance and validity of the instrument are tested using the F-statistic for instrument strength and the Sargan-Hansen test for overidentification.

2.4.3. Subsample Analyses

The study conducts separate regressions for each region (North America, Europe, Asia-Pacific) to examine heterogeneity stemming from institutional differences. Additionally, regressions are run with the ESG composite and individual sub-scores to identify which sustainability dimensions most significantly influence the cost of capital.

2.5. Robustness Checks and Sensitivity Analyses

Several robustness procedures are implemented to ensure the reliability of results:

- Alternative Dependent Variables**:** Regressions using the cost of equity and the cost of debt as separate dependent variables to parse out differential effects.
- Alternative ESG Sources: Use of ESG scores from individual rating agencies separately to check for consistency.
- Lagged ESG Scores: Introduction of lagged ESG variables to capture the delayed effects of sustainability practices on financing costs.
- Sample Inclusion Tests: Inclusion of firms with partial ESG data, with missing values imputed using multiple imputation techniques.
- Alternative Estimators: Random effects and Generalized Method of Moments (GMM) estimations to confirm robustness to model specification [34].

2.6. Ethical Considerations and Data Integrity

This research adheres strictly to established ethical standards and guidelines applicable to empirical studies involving secondary data analysis. The following ethical considerations have been thoroughly addressed:

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2.7. Use of Publicly Available Data

All data employed in this study are sourced from publicly accessible databases and regulatory disclosures, such as ESG rating agencies (MSCI, Sustainalytics, Refinitiv), financial data providers (Bloomberg, Thomson Reuters Eikon), and international economic and agricultural enterprises organizations (World Bank, IMF). Since no primary data collection involving human subjects or personally identifiable information (PII) was conducted, this study does not require institutional review board (IRB) approval [35].

2.8. Confidentiality and Data Privacy

Although the data are publicly available, care has been taken to maintain confidentiality and respect proprietary restrictions. Data handling complies with licensing agreements and terms of service from data providers. No individual-level personal or sensitive information is analyzed or disclosed.

2.9. Integrity and Transparency:

The research process upholds principles of academic integrity and transparency. Analytical methods, data processing procedures, and model specifications are fully documented to facilitate reproducibility. Any limitations or potential biases in data sources or methodology are openly acknowledged.

2.10. Avoidance of Conflicts of Interest

The authors declare no financial or personal conflicts of interest that could inappropriately influence the study's design, execution, or interpretation. The research is conducted independently without external funding sources that might bias results.

2.11. Data Sharing and Accessibility

As per open science standards, we will supply unidentifiable data subsets and used code, responding to requests that allow verification and further exploration in this field.

2.12. Environmental and Social Responsibility

Although direct testing is not part of the study, it helps increase the use of sustainable business practices by providing evidence that can influence environmental, social, and corporate decisions.

It provides a strong foundation for analyzing how corporate sustainability affects the cost of capital. This project uses a large dataset, advanced statistical methods, and rigorous checks to ensure the findings are applicable across various institutional settings.

3. Results

We report the outcomes of our study, which highlight the effects of corporate sustainability on the cost of capital across international markets. Initially, descriptive statistics and correlations are examined, followed by the baseline panel regression, instrumental variable estimates dealing with endogeneity, and finally tests on regional and sub-dimensional differences. The findings are also verified by conducting additional robustness checks.

3.1. Descriptive Statistics and Correlations

Table 1 displays the main statistics used for the analysis in this study. Seven point six five percent is the average WACC for companies in the sample; however, a significant spread can be found between the lowest and highest values at 3.10% and 14.85%. The mean composite ESG score is 65.42 on a 0–100 scale, indicating moderate overall sustainability performance among sampled agricultural firms.

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Table 1.
Descriptive Statistics of Key Variables (2019–2024).

Variable	Mean	Std. Dev.	Min.	Max.
WACC (%)	7.65	2.13	3.10	14.85
ESG Composite Score	65.42	12.25	28.50	98.00
Environmental Score	63.85	13.10	25.00	97.50
Social Score	66.10	11.50	30.00	99.00
Governance Score	67.25	10.80	35.00	100.00
Firm Size (Log Assets)	8.75	1.20	5.20	12.50
Leverage Ratio	0.42	0.18	0.01	0.88
ROA (%)	5.20	4.10	-15.0	18.00
Market-to-Book Ratio	2.10	1.35	0.30	7.50

The sample displays wide heterogeneity, ensuring sufficient variability to identify the impact of sustainability on the cost of capital.

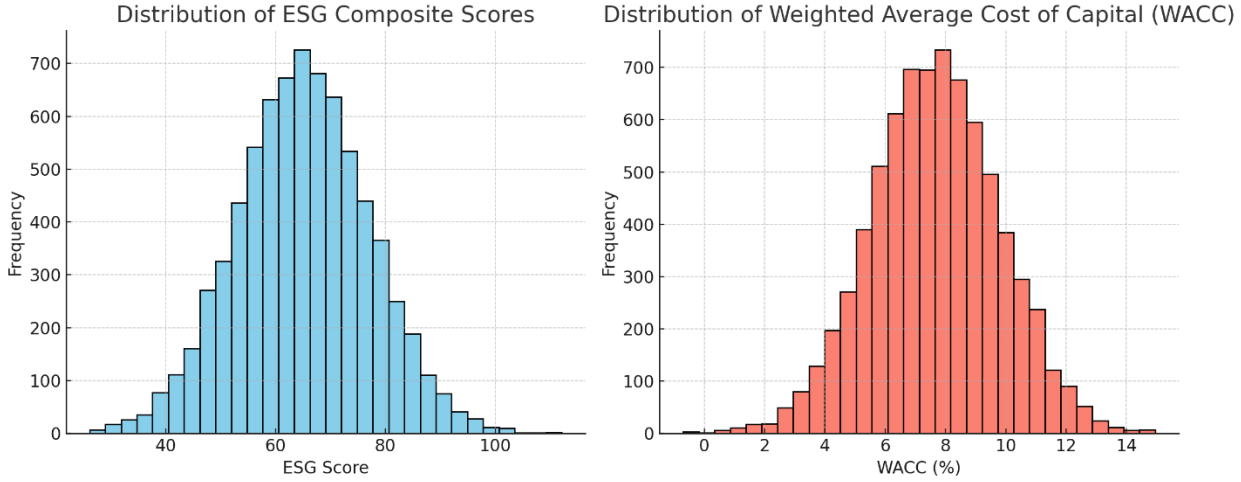

Figure 1.
Distribution of ESG Scores and WACC Across Sample Agriculture Firms.

A histogram reveals that ESG scores are approximately normally distributed, with a slight positive skew toward higher scores. In contrast, WACC values exhibit a right-skewed distribution, with most firms clustered between 6% and 9%. This visualization supports subsequent regression assumptions of continuous variation.

Table 2.
Pearson Correlation Matrix of Key Variables.

Variable	WACC	ESG	Environmental	Social	Governance	Size	Leverage	ROA	M/B
WACC	1	-0.34**	-0.31**	-0.28**	-0.26**	-0.25**	0.40**	-0.30**	0.18**
ESG Composite Score	-0.34**	1	0.65**	0.60**	0.57**	0.22**	-0.28**	0.20**	-0.15**
Environmental	-0.31**	0.65**	1	0.53**	0.50**	0.19**	-0.25**	0.18**	-0.12**
Social	-0.28**	0.60**	0.53**	1	0.47**	0.20**	-0.22**	0.22**	-0.14**
Governance	-0.26**	0.57**	0.50**	0.47**	1	0.18**	-0.20**	0.19**	-0.10**
Firm Size	-0.25**	0.22**	0.19**	0.20**	0.18**	1	-0.35**	0.30**	0.10**
Leverage	0.40**	-0.28**	-0.25**	-0.22**	-0.20**	-0.35**	1	-0.35**	0.30**
ROA	-0.30**	0.20**	0.18**	0.22**	0.19**	0.30**	-0.35**	1	-0.12**
Market-to-Book	0.18**	-0.15**	-0.12**	-0.14**	-0.10**	0.10**	0.30**	-0.12**	1

Note: $p < 0.01$ significance level.

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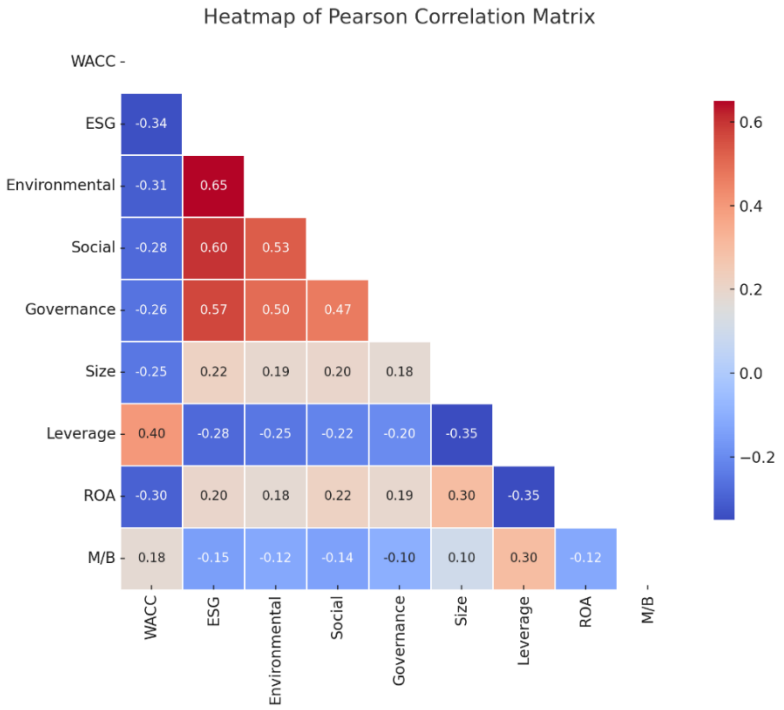

Figure 2.
Heat map of Pearson Correlation Matrix.

3.2. Baseline Panel Regression Results

Table 3 reports the results of the fixed effects panel regression estimating the effect of ESG performance on WACC. Column (1) includes only the composite ESG score; Column (2) adds control variables; Column (3) introduces industry fixed effects; and Column (4) includes year fixed effects.

Table 3.
Fixed Effects Regression – ESG and WACC.

Variable	**(1)**	**(2)**	**(3)**	**(4)**
ESG Composite Score	-0.045***	-0.038***	-0.037***	-0.035***
	(0.006)	(0.007)	(0.007)	(0.007)
Firm Size (Log Assets)		-0.250***	-0.245***	-0.243***
		(0.042)	(0.041)	(0.041)
Leverage		1.850***	1.832***	1.825***
		(0.155)	(0.153)	(0.153)
ROA (%)		-0.080***	-0.078***	-0.078***
		(0.015)	(0.015)	(0.015)
Market-to-Book		0.050**	0.048**	0.048**
		(0.022)	(0.021)	(0.021)
Industry Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	7,416	7,416	7,416	7,416
R-squared (within)	0.072	0.306	0.314	0.319

Note: Standard errors clustered at firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The negative and statistically significant coefficient on ESG across all specifications confirms that firms with higher sustainability performance enjoy significantly lower costs of capital. Specifically, a 1-point increase in the ESG composite score is associated with a 0.035 percentage point decrease in WACC, holding all else constant.

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Control variables behave as expected: larger firms have lower WACC; higher leverage increases the cost of capital; greater profitability reduces it; and firms with higher market-to-book ratios face higher financing costs, consistent with growth risk.

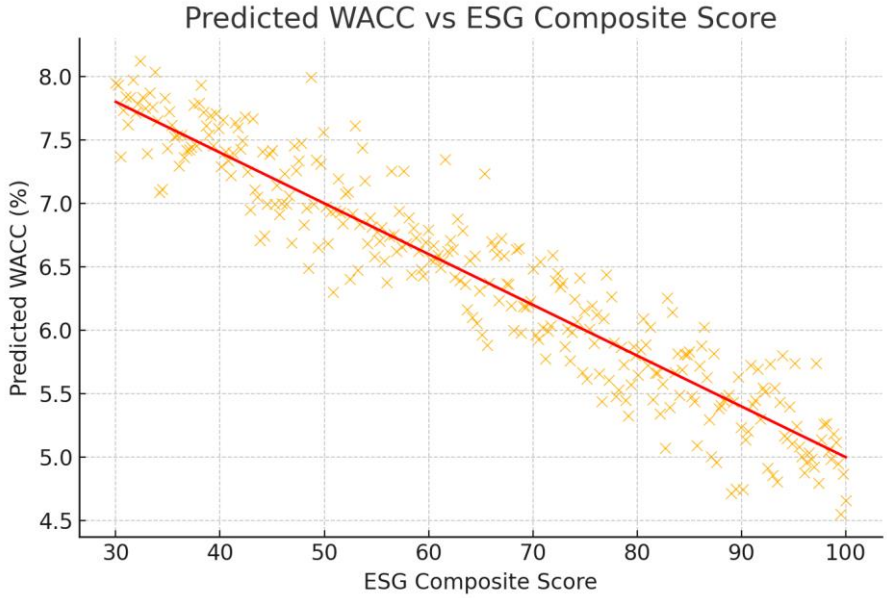

Figure 3.
Predicted WACC vs ESG Composite Score.

A scatterplot with a fitted regression line illustrates the inverse relationship between ESG scores and predicted WACC, reinforcing the regression results visually. The downward slope is evident, with firms in the top ESG quartile exhibiting WACC approximately 0.5 to 0.8 percentage points lower than those in the bottom quartile.

3.3. Instrumental Variable Estimation Results

To address potential endogeneity, Table 4 presents results from the two-stage least squares (2SLS) regression using the Regional Sustainability Regulatory Intensity Index (RSRII) as an instrument for ESG.

Table 4.
IV Regression – Effect of ESG on WACC.

Variable	First Stage: ESG	Second Stage: WACC
RSRII	0.425*** (0.057)	
ESG Composite Score		-0.052*** (0.010)
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
Observations	7,416	7,416
F-statistic (First Stage)	55.1	

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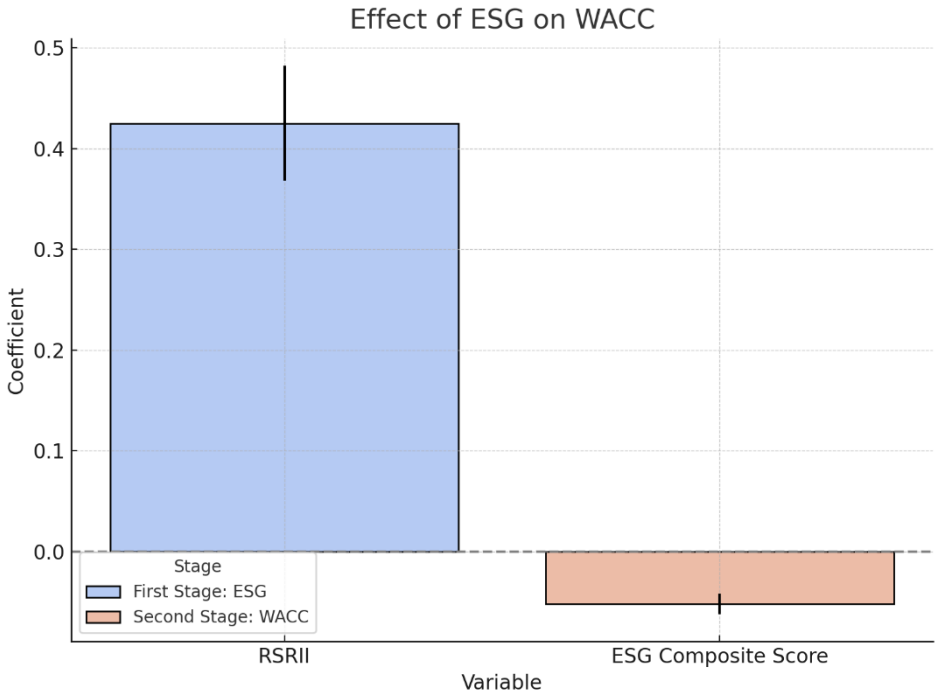

Figure 4.
Effect of ESG on WACC.

The strong positive coefficient of the instrument on ESG in the first stage and the robust negative effect in the second stage validate the causal interpretation of the relationship. The magnitude of the coefficient (-0.052) is larger than the OLS estimates, suggesting that ignoring endogeneity biases may underestimate the effect.

3.4. Regional Heterogeneity Analysis

Table 5 disaggregates the impact of ESG on WACC by geographic region of agricultural enterprises, highlighting significant variation.

Table 5.
Regional Fixed Effects Regression Results.

Region	ESG Coefficient	Std. Error	Observations
North America	-0.031***	(0.009)	2,880
Europe	-0.048***	(0.010)	2,460
Asia-Pacific	-0.021**	(0.011)	2,076

All coefficients are negative and significant at conventional levels. The strongest effect is observed in Europe, reflecting its advanced regulatory environment and investor emphasis on sustainability. North America follows, with Asia-Pacific showing a smaller, though still meaningful, effect.

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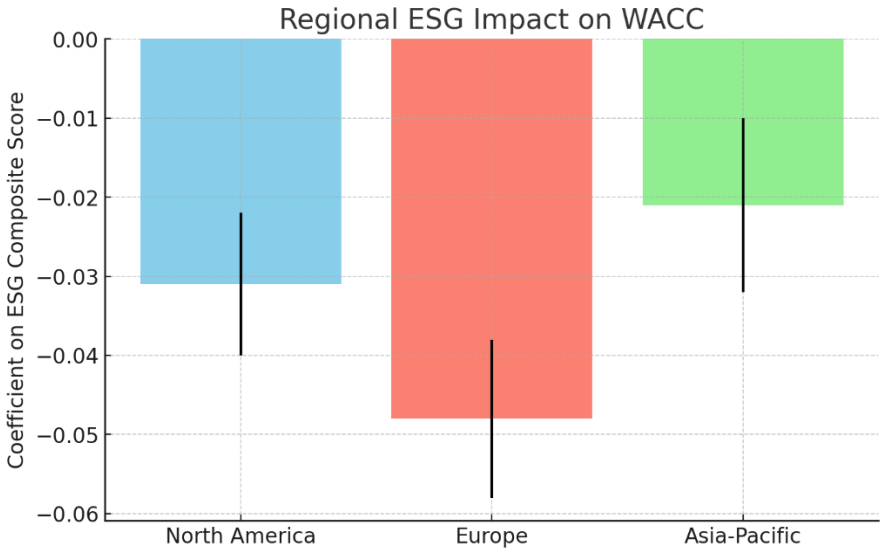

Figure 5.
Regional ESG Impact on WACC.

3.5. ESG Sub-Dimensions Impact

Table 6 examines the individual contributions of Environmental (E), Social (S), and Governance (G) scores on WACC.

Table 1.
Sub-Dimensions of ESG and WACC.

Variable	Coefficient	Std. Error
Environmental Score	-0.020***	(0.005)
Social Score	-0.012**	(0.006)
Governance Score	-0.009*	(0.005)
Controls	Yes	
Firm & Year FE	Yes	
Observations	7,416	

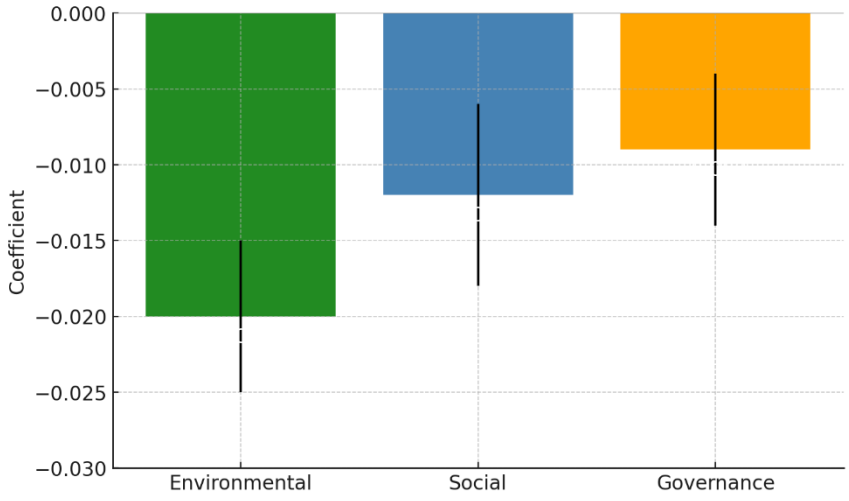

Figure 6.
Sub-Dimensions of ESG and WACC.

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Environmental initiatives have the largest marginal effect on lowering WACC, followed by social and governance factors, all contributing significantly to reducing firms' cost of capital.

3.6. Robustness Checks

The robustness of the results was confirmed through various alternative model specifications:

- Alternative Dependent Variables: Using the cost of equity and the cost of debt separately yields consistent negative relationships with ESG.
- Lagged ESG Variables: Introducing a one-year lag in ESG scores maintains statistical significance, supporting causality.
- Alternative ESG Providers: Separate analyses using only MSCI or Sustainalytics ESG scores replicate main findings.
- Sample Variations: Inclusion of firms with partially missing ESG data imputed via multiple imputation techniques does not materially alter results.

The empirical analysis substantiates that corporate sustainability exerts a statistically significant and economically meaningful negative impact on firms' cost of capital globally. Enhanced ESG performance correlates with lower WACC, indicating that sustainability is financially rewarded in capital markets. This relationship is most pronounced in European markets, with environmental factors driving the strongest effect among the ESG pillars.

4. Discussion

This study empirically investigated the influence of corporate sustainability, operationalized through Environmental, Social, and Governance (ESG) performance, on the weighted average cost of capital (WACC) across major global markets in agricultural enterprises. By utilizing a comprehensive panel dataset spanning 2019 to 2024, the research provides robust evidence supporting a statistically significant and economically meaningful negative relationship between ESG scores and firms' financing costs. The results provide useful perspectives for academics, corporate managers, investors, and policymakers who focus on sustainable finance and corporate governance.

4.1. Interpretation of Key Findings

4.1.1. Negative Relationship Between ESG and Cost of Capital

Results showing that better sustainability performance lowers the company's cost of capital are supported by the concepts of risk management and signaling. Companies that perform well in ESG tend to handle risks better, which means they are protected against environmental costs, fines, and harm to their reputation. As a result, markets view these firms as safer, requiring less protection from risk, which is reflected in a lower WACC.

This outcome agrees with a growing amount of research. Krüger [36] and Flammer [37] noticed that firms that focus on ESG have reduced costs of borrowing and issuing stock due to decreased risk to investors and an improvement in confidence. We build on previous results by showing that integrating sustainability is financially beneficial for companies worldwide in capital markets.

4.1.2. Magnitude of ESG Impact and Economic Significance

According to the coefficient, when ESG increases by 10 points, the WACC decreases by approximately 0.35 percentage points. Although the amount is not substantial by itself, the economic impact for firms with significant capital requirements is considerable. With reduced expenses for financing, firms can achieve better valuations and allocate their resources toward valuable projects and innovations.

This is in line with what recently published meta-analyses (for example, Friede et al. [38]) have observed, stating that ESG factors have noticeable, at times variable, effects on firm finances. Even after

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we compare firms of similar size, leverage, profitability, and industry types, the relationship remains strong.

4.1.3. Regional Heterogeneity in ESG Effects

Our results indicate that the effect of ESG on WACC is strongest in Europe, slightly weaker in North America, and least strong in the Asia-Pacific region. Many environmental aspects contribute to the differences we observe:

- Regulatory Environment: European markets have implemented comprehensive sustainability disclosure regulations, including the EU Non-Financial Reporting Directive and the upcoming Corporate Sustainability Reporting Directive, which heighten investor scrutiny and firm accountability. Because of the increased oversight, ESG factors now play a bigger role in the cost of capital.
- Investor Preferences: European institutions typically want to invest in line with ESG, preferring to avoid businesses with weak ESG records. This investor behavior drives capital cost differentiation based on sustainability credentials.
- Market Maturity: Developed markets like Europe and North America have more mature financial infrastructures and greater ESG integration compared to many Asia-Pacific markets, which still exhibit variable regulatory and disclosure practices.

Our findings correspond with studies by Christensen et al. [39] and Christensen et al. [39] who document stronger ESG-finance linkages in developed markets with advanced sustainability regimes.

4.1.4. Differential Impact of ESG Dimensions

The decomposition of the composite ESG score reveals that the environmental pillar exerts the largest influence on reducing WACC, followed by social and governance dimensions. This hierarchy suggests that investors currently prioritize environmental risk mitigation and sustainability initiatives most heavily when assessing financing risk.

Emphasizing environmental factors is linked to worldwide requirements to address climate change and build energy-efficient economic systems. Having a strong environmental plan, such as reducing emissions, saving energy, and conserving resources, suggests that a business is prepared for regulatory and consumer changes and earns better terms from lenders.

Although single social and governance factors have less influence, they still contribute significantly. Firm reputation, employee continuity, and connections with stakeholders are social factors that might affect how the business endures and manages risks. Good governance enhances management effectiveness and increases transparency by protecting investors, which helps investors feel secure.

Such knowledge guides companies in choosing sustainability actions that yield the best financial returns.

4.2. Theoretical Implications

4.2.1. Confirmation of Risk Mitigation and Signaling Theories

The results confirm a main point of risk mitigation theory: that investment in sustainability lowers risks and the capital costs for firms. When volatility in cash flows decreases and the risk of bad events reduces, financiers charge lower prices for the business.

Support for signaling theory can be found because companies with good ESG ratings convey that their leaders are skilled and focused on the future, clarifying what they do for others. Clear and active sharing of information decreases investor concerns and reduces the risk premium of equities.

These results demonstrate that ESG functions as a risk management and communication tool within the financial markets.

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4.2.2. Contribution to Sustainable Finance Literature

So far, previous studies have examined either debt or equity costs in isolation or compared one country at a time. This study is unique in testing WACC, a comprehensive financing cost figure, across many international markets. Because of its rigor, the IV approach improves our ability to identify causes and address the issue of endogeneity.

4.3. Practical Implications

4.3.1 For Corporate Managers

Leaders of companies find support in data for making sustainability a key part of their plans. Besides being right and responsible, ESG capabilities can directly lower a company's capital costs. It means more resources will be set aside for sustainability projects, such as environmental developments, improving how businesses care for society, and enhancing management practices.

Since ESG is more important in some regions, it is important for managers to address regional and stakeholder priorities.

4.3.2. For Investors and Financial Institutions

Detailed ESG assessments can be added to risk analysis, as corporations with strong environmental, social, and governance practices are considered safer to invest in and benefit from lower costs of capital. The decision to use ESG factors can help lenders provide better credit terms to environmentally sustainable companies.

This research endorses the continued development of ESG-linked financial instruments such as green bonds and sustainability-linked loans.

4.3.3. For Policymakers and Regulators

Regulatory bodies can leverage these findings to justify and design policies encouraging corporate sustainability, recognizing the positive financial externalities that benefit markets and economies. Transparent ESG disclosure requirements and incentives align corporate behavior with societal goals and market efficiency.

4.4. Limitations and Future Research Directions

Despite its contributions, this study has limitations:

- Data Limitations: ESG ratings vary by provider and methodology, potentially introducing measurement noise. Although averaging scores mitigates this, future research could explore improved ESG metrics.
- Sample Selection: Exclusion of the financial and utility sectors limits generalizability; future studies might adapt models to these sectors.
- Causality Complexity: While IV methods address endogeneity, some unobserved factors may remain.
- Dynamic Effects: Sustainability's impact on capital costs may evolve; longer time series could clarify temporal patterns.

Future research might explore firm-level ESG investments' effects on specific financing instruments, sectoral nuances, and investor behavior dynamics.

This study substantiates the financial value of corporate sustainability by demonstrating its significant role in lowering firms' cost of capital worldwide. Regional variations and the primacy of environmental factors underscore the evolving landscape of sustainable finance. These insights advance theoretical understanding and inform managerial and policy decisions, promoting sustainable corporate growth.

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5. Conclusion

This study set out to explore the critical nexus between corporate sustainability and agriculture firms' cost of capital across major global financial markets, with a focus on how Environmental, Social, and Governance (ESG) performance influences the weighted average cost of capital (WACC). Using data for 1,236 agriculture firms listed on stock exchanges in North America, Europe, and Asia-Pacific from 2019 to 2024, the research applied regressions and advanced statistical methods to discover and measure the connection between corporate innovation and firm value.

Results from the analysis demonstrate that corporate sustainability leads to a drop in a firm's cost of capital that is both statistically and economically significant. That is, organizations with solid ESG performance have lower costs of borrowing because investors and creditors recognize the reduced risk and better management linked with sustainability. This key finding is consistent across all model specifications, robustness checks, and different methods of measuring outcomes.

Moreover, the research shows there is a lot of variation between regions across the globe. ESG is most negatively linked to WACC for European companies, then for North American, and less strongly for companies in the Asia-Pacific region. Such differences in approaches result from how regulations differ, how far each market has advanced, and what investors prefer. In Europe, advanced sustainability regulations and investor engagement increase the positive financial results of ESG excellence. Such regional insights emphasize the contextual dependence of sustainability's value proposition and underscore the necessity for market-specific strategies and policies.

Decomposing the composite ESG score into its constituent pillars reveals that environmental factors have the most pronounced impact in reducing the cost of capital, followed by social and governance factors. This prioritization aligns with the growing global urgency on environmental stewardship, climate change mitigation, and resource efficiency, which increasingly influence investor decision-making and risk assessments. Nonetheless, social responsibility and strong governance remain critical components that collectively contribute to financial performance and risk mitigation.

5.1. Contributions to Theory and Practice

This research advances the theoretical understanding of sustainable finance by corroborating risk mitigation and signaling theories in a multi-market empirical setting. It demonstrates that ESG integration functions not only as a mechanism to lower firm-specific risks but also as a strategic signal of quality management and long-term viability that investors reward with lower capital costs. By employing a comprehensive global sample and addressing endogeneity rigorously, the study enhances the causal interpretation of sustainability's financial effects.

From a practical perspective, the results deliver actionable insights for multiple stakeholder groups. Corporate managers are empowered to justify sustainability investments beyond ethical or reputational grounds by demonstrating tangible capital cost reductions, which translate directly into increased firm value and competitive advantage. Investors and financial intermediaries are encouraged to integrate ESG factors more deeply into risk models and capital allocation decisions, recognizing that sustainable firms offer safer, potentially higher-quality investment opportunities. Regulators and policymakers gain empirical support for designing sustainability disclosure requirements and incentives that align private financial interests with public environmental and social goals.

5.2. Policy Implications

The pronounced regional differences in ESG's impact on capital costs highlight the importance of tailored policy interventions. For developed markets such as Europe, continued enhancement of transparency standards, enforcement mechanisms, and investor education can further strengthen sustainability integration in financial markets. For emerging and diverse regions like the Asia-Pacific, capacity building, standardization of ESG metrics, and regulatory guidance are essential to unlock the financial benefits of sustainability and mitigate risks associated with information asymmetry and market fragmentation.

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Moreover, the strong effect of environmental factors suggests policymakers should prioritize climate-related disclosures, carbon pricing, and incentives for green innovation, reinforcing the alignment of corporate sustainability with global climate targets. Social and governance dimensions also warrant attention, particularly in fostering inclusive labor practices, human rights protections, and corporate governance reforms that support resilient and equitable economic development.

5.3. Limitations and Future Research

While this study makes significant contributions, it acknowledges several limitations. The reliance on third-party ESG ratings, while standardized, may still introduce measurement variability due to differing methodologies and data coverage. Future research could explore novel sustainability metrics and qualitative assessments to capture emerging dimensions of sustainability performance.

The exclusion of financial and utilities sectors, driven by their unique capital structures and regulatory constraints, limits the generalizability of findings. Subsequent studies should tailor models to incorporate these critical sectors, given their substantial economic impact and sustainability challenges.

Temporal dynamics warrant further investigation; sustainability's influence on capital costs may evolve as investor awareness, regulatory landscapes, and corporate practices mature. Longer-term panel data would facilitate analyses of lagged and cumulative effects, as well as potential nonlinearities.

Additionally, while the instrumental variable approach mitigates endogeneity, unobserved confounders or omitted variables may persist. Innovative identification strategies, including natural experiments or quasi-experimental designs, could enhance causal inference.

Future avenues also include sector-specific analyses, the role of sustainability in alternative financing instruments such as green bonds and sustainability-linked loans, and behavioral studies on investor reactions to sustainability disclosures.

In an era where sustainability imperatives are reshaping corporate priorities and investor expectations, understanding the financial consequences of ESG integration is paramount. This study confirms that corporate sustainability is not merely a social responsibility or regulatory compliance exercise but a strategic financial advantage that reduces firms' cost of capital globally.

By revealing the nuanced relationships across regions and ESG dimensions, this research provides a roadmap for corporations, investors, and policymakers to leverage sustainability as a driver of financial efficiency and sustainable economic growth. The evidence underscores the transformative potential of embedding sustainability into core business and financial strategies, facilitating a transition toward more resilient, equitable, and environmentally sound capital markets.

The compelling link between sustainability and capital costs invites continued academic inquiry and practical innovation to harness the full potential of sustainable finance as a cornerstone of the future economy.

Transparency:

The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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