



ESG PERFORMANCE AND PROFITABILITY IN VIETNAMESE AGRICULTURAL FIRMS: PANEL AND PREDICTIVE EVIDENCE

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Article DOI: <https://doi.org/10.36713/epra31658>

DOI No: 10.36713/epra31658

ABSTRACT

Whether environmental, social, and governance (ESG) investment improves firm profitability remains uncertain in agriculture, where sustainability initiatives may reduce operating risks but require substantial up-front costs. This study examines the relationship between ESG performance and return on assets (ROA) using an unbalanced panel of 683 firm-year observations from 78 Vietnamese agricultural firms during 2016–2025. Firm and year fixed-effects models are employed, supplemented by lagged specifications, production-system comparisons, and a limited predictive analysis using Elastic Net and Random Forest. The results show that aggregate ESG performance is not significantly associated with profitability, while governance exhibits a positive relationship with ROA. The financial relevance of ESG also varies across production systems, with stronger effects observed among livestock firms and differences in the environmental dimension between livestock and crop production. Predictive improvements from nonlinear machine-learning models are limited. Overall, the findings suggest that ESG–profitability relationships in agriculture are primarily pillar- and production-specific rather than reflecting a uniform ESG premium.

KEYWORDS: ESG performance; Profitability; Agricultural Firms; Fixed Effects; Production Heterogeneity; Predictive Modelling.

1. INTRODUCTION

For agricultural firms, ESG performance is tied directly to production decisions rather than only to disclosure practice. Water use, fertilizer management, animal health, energy consumption, waste treatment, labour conditions, traceability, and board oversight can affect costs and operating continuity. The same measures can also require capital before any financial benefit appears. This makes the ESG-profitability relationship unusually dependent on production technology, biological cycles, and the timing of investment. Broad reviews find that ESG-financial associations are more often non-negative than negative, but they also document substantial variation across measures, industries, and research designs (Friede et al., 2015; Gillan et al., 2021). Rating disagreement adds a further measurement problem because different ESG systems need not capture the same underlying construct (Berg et al., 2022).

Studies of agricultural firms have reached different conclusions about ESG and financial performance. Buallay (2021), using a global agricultural sample, finds little evidence that aggregate ESG improves ROA, ROE, or Tobin's Q, whereas Zeng and Jiang (2023) report a positive association for Chinese agriculture and forestry firms. European evidence also varies across ESG pillars and disclosure practices (Conca et al., 2021; Cristea et al., 2024; Pirtea et al., 2021). One reason may be that ESG activities enter production differently. Environmental spending in crop production, for example, may involve irrigation, soil restoration, or changes in input use, while livestock firms face waste, emissions, water, and biosecurity requirements. Combining these activities in a single ESG score can obscure their different cost and return profiles.

Vietnam offers a relevant setting because sustainability reporting among listed firms has expanded, although quantitative ESG records remain uneven across firms and years. Nguyen and Nguyen (2024) find that ESG engagement in Vietnam is associated with stronger accounting performance but not with excess market returns. This study focuses on two questions: how aggregate ESG and the three ESG pillars relate to changes in ROA within firms, and whether these relationships vary among crop/perennial-crop, livestock, and integrated/ high-tech producers. The empirical analysis uses firm and year fixed effects, followed by a one-year lag specification and production-group comparisons. A separate forecasting exercise compares linear and nonlinear models on a time-based holdout sample.



2. LITERATURE REVIEW

Several mechanisms link ESG practices to financial performance. Stakeholder theory emphasizes relationships with employees, customers, lenders, regulators, and local communities: safer work practices, credible product standards, and stronger governance may reduce conflict and transaction costs (Freeman, 1984). The resource-based view emphasizes internal capabilities. Traceability, resource-efficiency routines, risk controls, and managerial systems can become operating assets when they are embedded in the firm and difficult to replicate (Barney, 1991). These benefits may take time to emerge because certification, environmental equipment, reporting systems, and process redesign also absorb capital and managerial resources (Eccles et al., 2014).

These mechanisms are especially relevant in agriculture. Irrigation upgrades, pollution control, waste treatment, renewable energy, precision inputs, and soil restoration may improve resource efficiency or reduce production losses, but they can also raise short-run costs. Social practices affect labour continuity, food safety, and supplier relationships, while governance shapes investment discipline, audit quality, and risk oversight. Prior agricultural studies report different results across these dimensions. Buallay (2021) finds weak aggregate relationships with some governance-related financial relevance; Zeng and Jiang (2023) identify stronger social and governance contributions; and European studies report varying pillar effects (Conca et al., 2021; Pirtea et al., 2021). H1: higher ESG performance is associated with higher ROA, with the strength of the association varying across environmental, social, and governance performance.

Production systems may further alter these relationships. Crop firms depend heavily on land quality, irrigation, input efficiency, and biodiversity. Livestock firms face feed, water, emissions, waste, biosecurity, and product-safety risks. Integrated/high-tech firms rely more on energy efficiency, automation, sensors, and traceability. An improvement recorded under the same ESG pillar can therefore change costs and operating risk through different production channels. H2: the ESG-ROA relationship differs across agricultural production models. The analysis also estimates a one-year lag as a timing check. For forecasting, Elastic Net provides a regularised linear benchmark and Random Forest captures possible nonlinear patterns (Breiman, 2001; Zou & Hastie, 2005).

3. METHODOLOGY

3.1. Data, sample, and measurement

The study uses the enterprise panel data from 2016-2025. It contains 683 firm-year observations for 78 firm identifiers: 34 crop/perennial-crop firms, 24 livestock firms, and 20 integrated/high-tech firms. The corresponding observation counts are 306, 215, and 162. The firms are distributed across HOSE, HNX, and UPCoM labels.

ROA is the principal outcome because it measures profitability relative to the asset base. ROE and net profit margin are used only in a focused robustness check of the governance result. Environmental (ENV), social (SOC), and governance (GOV) scores are standardised before estimation. Aggregate ESG is analysed in a separate specification so that it is not entered mechanically alongside its component pillars. ESG disclosure remains a control rather than a performance measure. The control vector includes log assets, leverage, liquidity, revenue growth, capital intensity, export share, biological-asset intensity, ESG disclosure, and a climate-stress index. The dataset flags 27 observations as outliers; these are retained in the baseline and removed in a sensitivity estimate.

Table 1. Sample composition and descriptive indicators

Indicator	Value	Indicator	Value
Firms	78	Firm-year observations	683
Period	2016-2025	Panel structure	Unbalanced
Crop observations	306	Livestock observations	215
Integrated/ high-tech observations	162	Flagged outliers	27 (4.0%)
Mean ROA	3.21%	Mean ESG score	60.60
Mean ENV / SOC	63.30 / 59.26	Mean GOV	58.38
Mean disclosure score	56.71	ML train / validation / test	487 / 78 / 118
HOSE / HNX / UPCoM firms	25 / 15 / 38	Observation years	2016-2025

3.2 Econometric specification

The main specification is a two-way fixed-effects model with standard errors clustered by firm. Firm effects absorb time-invariant differences in business model, management structure, and other persistent characteristics, while year effects capture shocks shared across firms. Pooled OLS is reported only as a descriptive reference. Because ESG variables are standardised, beta measures the ROA change associated with a one-standard-deviation change in the relevant ESG measure, conditional on the observed controls:



$$ROA_{it} = \alpha + \beta ESG_{it} + \gamma'X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

A second specification replaces aggregate ESG with ENV, SOC, and GOV, allowing the three pillars to be estimated separately. A one-year lag of aggregate ESG tests whether the contemporaneous specification misses a delayed relationship. Production heterogeneity is examined through fixed-effects models for each production group and pooled interaction terms relative to crop/perennial-crop firms. Robustness checks exclude the 27 flagged outliers and re-estimate the governance relationship using ROE and net profit margin. The fixed-effects coefficients are interpreted as within-firm conditional associations in this observational panel.

3.3 Complementary prediction exercise

The forecasting sample follows the time order of the panel: 487 observations are used for training, 78 observations from 2023 for validation, and 118 observations from 2024-2025 for testing. Predictors include ESG pillars and underlying indicators, disclosure measures, financial controls, technology adoption, and climate exposure. Direct arithmetic components of ROA are excluded to prevent target leakage. Linear regression serves as an unregularised reference, Elastic Net as the regularised linear model, and Random Forest as the nonlinear alternative. Hyperparameters are selected using the validation period; the tuned models are then refitted on the combined training and validation data. Performance is evaluated on the same holdout using RMSE, MAE, and out-of-sample R-squared. The comparison tests whether nonlinear structure improves forecasting beyond the regularised linear benchmark.

4. RESULTS

4.1 ESG profile and disclosure development

The panel shows a gradual rise in ESG performance. Mean ESG increases from 55.26 in 2016 to 65.17 in 2025, while the disclosure score rises more sharply from 45.20 to 68.76. The share of firm-year records with a sustainability report increases from 17.8% to 69.8%, and greenhouse-gas disclosure rises from 6.7% to 54.7%. The mean number of quantitative ESG indicators reported also increases from 18.1 to 29.4. Disclosure and performance are related but not interchangeable: their correlation is 0.422, sufficiently moderate to justify modelling disclosure separately. Mean ESG is similar across production models (60.96 for crop, 60.40 for livestock, and 60.20 for integrated/high-tech), but pillar composition differs. Livestock records have the highest mean ENV score (64.19) and the lowest mean GOV score (56.96), illustrating how an aggregate score can conceal production-specific configurations.

4.2. Baseline and timing estimates

Aggregate ESG has a positive coefficient in both pooled OLS (0.0032, $p = .211$) and the firm-and-year fixed-effects model (0.0024, $p = .345$), but neither estimate is statistically significant. The pillar specification yields a different pattern. ENV and SOC are small and statistically imprecise (0.0003 and 0.0026; $p = .901$ and $.281$), while GOV is positive at 0.0048 ($p = .038$). Because the pillar scores are standardised, the GOV coefficient corresponds to approximately 0.48 percentage points of ROA for a one-standard-deviation increase in governance performance, equivalent to about 15% of mean ROA in the sample. These results provide partial support for H1, with the statistically significant relationship concentrated in governance.

The lagged aggregate ESG coefficient is -0.0005 ($p = .857$; $N = 605$), so the one-year specification does not reveal a delayed relationship with ROA. The governance result is also stable when the 27 flagged observations are removed: the coefficient is 0.0049 ($p = .031$). Using alternative profitability measures, GOV remains positive for ROE (0.0106, $p = .018$) and net profit margin (0.0082, $p = .018$). Across these specifications, governance shows the most stable positive association with accounting profitability.

Table 2. Context-specific conditional logit estimates

Variable	Overall ESG	Pillars	Lagged ESG
ESG (z)	0.0024	-	-
ENV (z)	-	0.0003	-
SOC (z)	-	0.0026	-
GOV (z)	-	0.0048*	-
ESG t-1 (z)	-	-	-0.0005
ESG ² (z)	-	-	-
Observations	683	683	605
R ²	0.457	0.461	0.469

Note. Firm and year fixed effects are included in all models; standard errors are clustered by firm.



4.3 Production-model heterogeneity

The relationship between ESG and ROA varies across production groups. For livestock firms, aggregate ESG has a positive coefficient of 0.0104 ($p = .006$). The estimates for crop/perennial-crop firms (-0.0053, $p = .176$) and integrated/high-tech firms (0.0019, $p = .684$) are not statistically significant. The environmental pillar shows the largest difference: ENV is negative in the crop subsample (-0.0082, $p = .035$) and positive in livestock (0.0096, $p = .008$). In the pooled interaction model, the livestock ENV coefficient differs significantly from the crop reference ($p = .041$), whereas the aggregate ESG interactions are not significant. The evidence for H2 is therefore concentrated in environmental performance rather than in the composite ESG measure.

Table 3. Production-model heterogeneity in ROA

Variable	Crop / perennial	Livestock	Integrated / high-tech
Overall ESG (z)	-0.0053	0.0104**	0.0019
ENV (z)	-0.0082*	0.0096**	-0.0016
SOC (z)	-0.0013	-0.0001	0.0077
GOV (z)	0.0036	0.0086	0.0029
Observations	306	215	162

*Note. Separate fixed-effects models are estimated by production group. * $p < .05$; ** $p < .01$.*

4.3 Out-of-sample prediction

Forecast accuracy remains low across the three models. Linear regression records a test RMSE of 0.04131 and an out-of-sample R-squared of -0.0715. Elastic Net improves RMSE to 0.03932 and R-squared to 0.0294. Random Forest reaches an out-of-sample R-squared of 0.0300. The small out-of-sample R-squared values indicate that the available predictors explain little of the variation in ROA during 2024-2025. In this sample, adding nonlinear model structure produces limited additional forecasting information beyond regularisation.

Table 4. Time-based holdout prediction of ROA

Model	RMSE	MAE	Out-of-sample R ²
Linear regression	0.04131	0.03278	-0.0715
Elastic Net	0.03932	0.03109	0.0294
Random Forest	0.03764	0.03146	0.0300

5. DISCUSSION

The results show why the financial content of ESG can be lost when environmental, social, and governance practices are compressed into one index. Aggregate ESG remains positive after firm and year effects are introduced, but the coefficient is not statistically significant. This is similar to Buallay's (2021) agriculture-wide result and differs from the broader positive relationship reported by Zeng and Jiang (2023). The pillar estimates help explain this divergence. Board oversight and environmental investment do not alter costs and operating performance through the same channels, and firms can improve one dimension while leaving others unchanged. A composite score averages these changes and may therefore weaken relationships that are visible at the pillar level.

Governance provides the strongest result in the pillar analysis. Its positive association with ROA persists after outlier exclusion and when profitability is measured by ROE or net profit margin. This pattern is economically relevant for agricultural firms because investment discipline, audit quality, related-party oversight, biosecurity planning, and climate-risk governance affect asset use and exposure to operational disruption. The result is also consistent with stakeholder and resource-based explanations of how internal controls and managerial capabilities can support financial performance. As specified in the methodology, the coefficient is an observational within-firm estimate rather than an intervention effect.

Production technology changes the pattern further. Livestock firms show a positive ESG-ROA relationship, while the environmental coefficient is positive for livestock and negative for crop/perennial-crop firms. Environmental expenditure in livestock operations often addresses waste treatment, water use, emissions, animal health, and biosecurity, all of which can affect losses and production continuity. Crop firms may incur substantial early costs for irrigation systems, soil restoration, biodiversity measures, or changes in input use, with returns emerging over longer production cycles. The negative crop ENV coefficient may therefore reflect investment timing and production conditions in the observed period rather than the long-run value of environmental management.



The forecasting exercise adds little evidence for complex nonlinear prediction. Elastic Net and Random Forest explain only about 3% of out-of-sample ROA variation on the 2024-2025 holdout. For this dataset, model complexity does not compensate for the limited predictive information contained in the available ESG and firm-level variables. The more informative distinction comes from the panel estimates: governance should be analysed separately, and environmental indicators need to be interpreted in relation to the production system. For investors and lenders, these measures can complement conventional financial screening. For regulators, more stable quantitative reporting on emissions, water, waste, safety, traceability, and board oversight would improve comparability across agricultural firms.

6. CONCLUSION

For Vietnamese agricultural firms in this sample, the financial relevance of ESG differs by pillar and production system. Aggregate ESG is not significantly related to ROA in the firm-and-year fixed-effects model, whereas governance has a positive association with accounting profitability. Production-group estimates also identify a marked environmental difference between livestock and crop/perennial-crop firms. The forecasting models explain little out-of-sample variation in ROA, and nonlinear modelling adds limited predictive value. These findings support analysing ESG through the operating characteristics of agricultural production rather than assuming that a composite score has the same financial meaning across firms.

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