

Measuring and Mitigating ESG Risks in Europe: Integrating Qualitative and Quantitative Data Using Artificial Intelligence

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Abstract:

Purpose: This article develops and tests an integrated ESG-based early-warning framework for detecting corporate misconduct by combining qualitative (“soft”) disclosures with quantitative (“hard”) ESG indicators. The study responds to the limits of conventional ex post risk-detection approaches that rely heavily on financial anomalies and may identify misconduct only after reputational and financial damage has occurred. By treating ESG as an informational system, simultaneously expressed in narrative commitments and measurable outcomes, the article examines whether a joint soft–hard ESG architecture improves the prediction and discrimination of future misconduct relative to models built on single-source ESG information or standard machine-learning baselines.

Design: The research design is predictive and comparative. We build a modelling pipeline that (i) constructs E/S/G measures from text and numerical indicators; (ii) integrates these measures into composite ESG indices; and (iii) evaluates misconduct prediction performance against alternative algorithms and against ablated specifications that isolate text-only or numeric-only ESG information. The validation strategy emphasises discrimination and early-warning usefulness under class imbalance, and includes robustness checks that compare nonlinear (Autoencoder-based) versus linear (PCA-based) dimensionality reduction for ESG index construction.

Data: The study focuses on firms included in the STOXX Europe 600 over the period 2010–2025. Two complementary data streams are planned. First, qualitative textual data are extracted from corporate extra-financial reports and other sustainability-related disclosures. These texts provide narrative content that can be systematically transformed into quantitative predictors. Second, the study uses structured, quantitative indicators capturing environmental, social, and governance performance. The combination is designed to reflect ESG both as measurable outcomes (“hard” metrics) and as corporate communication (“soft” disclosures), enabling the analysis of predictive content arising from each stream and, crucially, from their joint integration.

Methods: Soft information is operationalised through a multi-method NLP pipeline. First, ESG-relevant sentences are extracted and partitioned into E/S/G categories using a structured large-language-model extraction procedure designed to maximise recall while preserving original wording. Second, semantic embeddings are generated and used with BERTopic to identify interpretable ESG themes and to produce document–topic probability distributions that serve as quantitative features. Third, dictionary-based ESG term frequencies complement topic features to capture transparent, easily auditable textual signals. Hard information is represented by a set of numerical indicators mapped to E/S/G dimensions. To integrate heterogeneous features and address high dimensionality, the article constructs composite E/S/G indices using an Autoencoder (nonlinear representation learning). The prediction model is a Lasso-penalised logistic regression, selected for its ability to manage high-dimensional predictors while retaining interpretability through sparse feature selection. Predictive performance is assessed with multiple metrics suited to imbalanced classification (including