Chapter 6
Algorithmic Modeling of ESG Contingencies Using Intelligent Analytics and Predictive Parameterization of Corporate Risk

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ABSTRACT

This study presents a hybrid intelligent analytics architecture that merges low-orbit satellite data, IoT sensors, multilingual digital narratives, and extended financial statements using interoperable ontologies to model ESG contingencies and parameterize corporate risk. Deep neural networks are combined with hierarchical Bayesian graphs and Shapley explainability metrics, allowing environmental, social, and reputational incidents to be anticipated with greater sensitivity than traditional approaches. The responsible algorithmic governance framework, underpinned by ethical licensing and continuous audits, ensures transparency and multi-group fairness, balancing intellectual protection and accountability. Case studies in the energy, financial, and logistics sectors show substantial reductions in prediction errors, capital buffers, and stock market drawdowns, while strengthening supply chain resilience and management acceptance.

DOI: 10.4018/979-8-3373-5142-1.ch006

INTRODUCTION

The confluence between sustainability and data analytics has shifted the center of gravity of corporate management from process efficiency to the ability to anticipate systemic contingencies, integrate socio-environmental externalities, and turn transparency into a tangible asset. Over the past two decades, academia and multilateral bodies have insisted that stock market value increasingly depends on the legitimacy that organizations project through environmental, social and governance metrics, while the climate crisis and reputational surveillance on networks impose scrutiny that was unimaginable in the era of financial statements based solely on tangible assets. This shift produces a scenario where deep learning algorithms process signals from low-orbit satellites, Internet of Things sensors, and multilingual digital narratives, linking them to financial statements in extensible formats that overcome the limitations of classical accounting language (Bhandari, Pokhrel, Rimal, & Dahal, 2024). The intensification of this flow of data has multiplied the speed with which stakeholder expectations are converted into changes in the cost of capital, so that competitive advantage is now measured by the ability to translate ethical barriers and climate risks into quantifiable indicators before they manifest themselves as irreversible losses.

However, the promise of transparency is undermined by persistent semantic fragmentation. Current reporting standards use identical terms to describe divergent realities, which prevents the construction of comparable historical series and, consequently, weakens the calibration of corporate risk models. This fracture is not just a matter of terminology: by confusing emissions intensity with absolute footprint or social capital with community commitment, organizations distort the materiality of data and sacrifice predictive accuracy (Matentzoglu, Balhoff, Bello, & Bizon, 2021).

Faced with this gap, interoperable ontologies emerge as an essential scaffolding. By defining classes, properties, and formal constraints, they allow algorithms to align glossaries, detect redundancies, and enable Bayesian imputation when series have missing values. This semantic fabric enables federated queries that combine accounting information, weather sensors and opinion columns in the same graph, transforming an ocean of dispersed indicators into strategic knowledge. When shared semantics are coupled with smart contracts that ensure the immutability of records, the data chain of custody is fortified, reducing the risk of tampering and facilitating near-real-time audits.

The resulting statistical sophistication brings with it a governance dilemma: the models with the highest predictive power are often the least transparent, as the deep layers of neural networks encode nonlinear relationships that are difficult to verbalize. This opacity increases the risk premium when governing bodies cannot

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