Renewable energy technology innovation and ESG greenwashing : Evidence from supervised machine learning methods using patent text

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Introduction

- **Background:**

ESG greenwashing undermines stakeholders' ability to assess corporate transparency and accountability, while growing evidence shows it can erode reputation, stakeholder trust, and long-term performance. Therefore how to How to curb corporate ESG greenwashing is particularly important.

- **Research Gap:**

Previous studies identify organizational structures, consumer demand, and regulatory pressures as key drivers of ESG greenwashing, often leading firms to prioritize symbolic over substantive sustainability efforts. However, the role of renewable energy technology innovation (RETI) in influencing greenwashing remains underexplored, raising the question of whether RETI fosters genuine CSR engagement or mitigates greenwashing behavior.

- **Contributions:**

1. This study advances ESG greenwashing research by identifying renewable energy technology innovation (RETI) as a key driver, providing new empirical evidence, particularly in transitional economies like China.

2. It integrates institutional and corporate governance theories, highlighting how board experiential diversity and media attention moderate the RETI and ESG greenwashing relationship, strengthening internal and external monitoring mechanisms.

3. The study enhances strategic behavior research by refining RETI assessment frameworks, advocating for advanced metrics beyond financial indicators, and leveraging machine learning to improve qualitative and quantitative evaluations.

Objectives

- To explore how RETI curbs corporate ESG greenwashing.
- To explore how board experiential diversity moderates the relationship between RETI and ESG greenwashing.
- To explore how media attention moderates the relationship between RETI and ESG greenwashing.

Framework

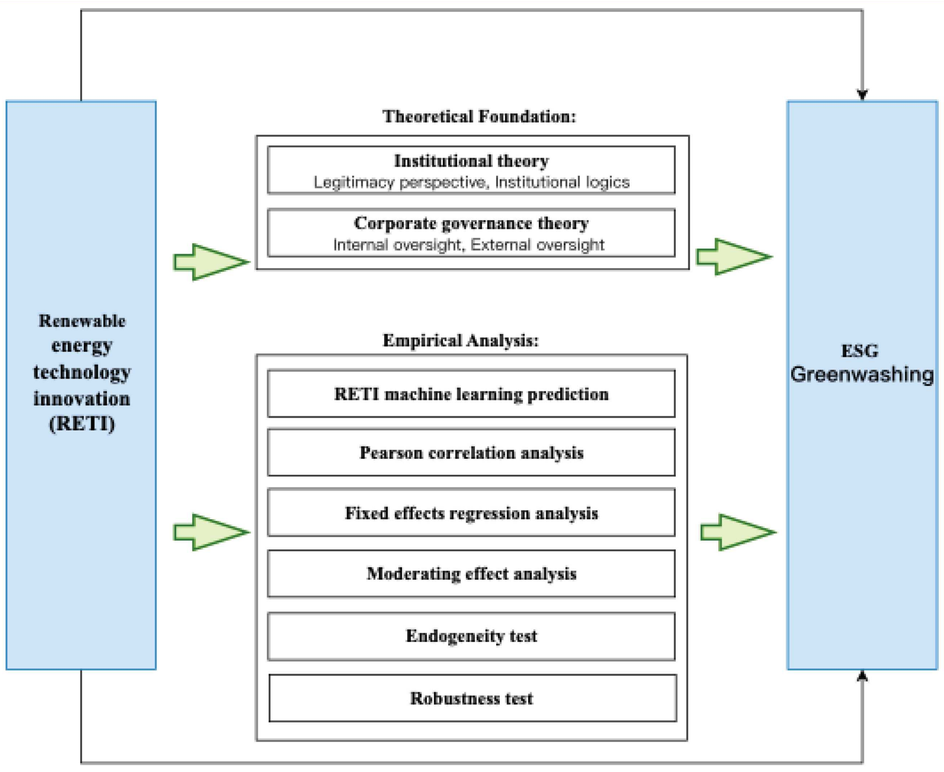

Fig.1 Conceptual Framework

- **H1:**Renewable energy technology innovation has a negative impact on ESG greenwashing.
- **H2:**Board experiential diversity strengthens the negative impact between Renewable energy technology innovation and ESG greenwashing.
- **H3:**Media attention strengthens the negative impact between renewable energy technology innovation and ESG greenwashing.

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Methods

- **Data:** 10-year panel data (2012–2022) from Chinese listed firms (14,970 observations).
- **Variables:** ESG greenwashing (explanatory), RETI (dependent), and controls (e.g., Lev, Size).
- **Machine learning to measure RETI:**

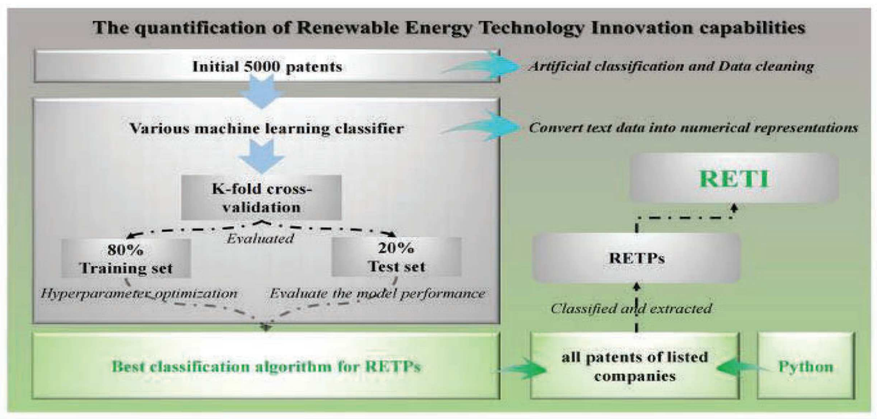


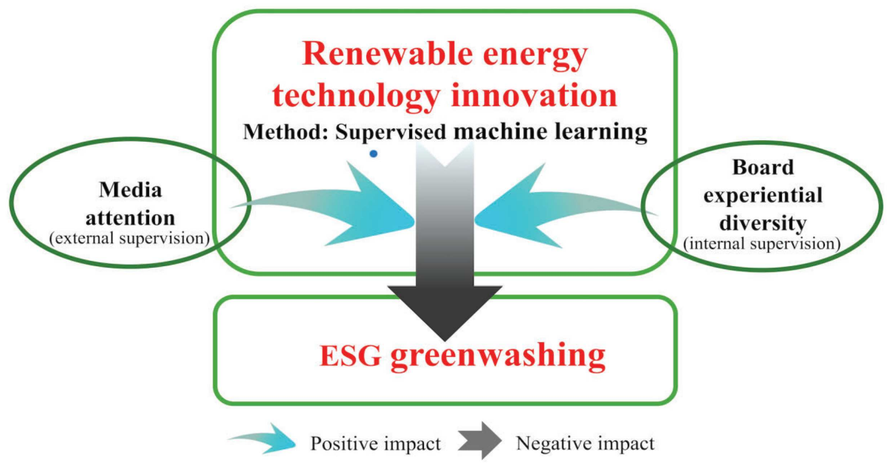
Fig.2 RETI computational process

This study constructs a manually classified dataset of 5000 patents (40% RETPs) to train a machine learning classifier. The Bag-of-Words (BOW) model converts text into numerical representations for classification, with K-fold cross-validation ensuring robust performance evaluation. Using Python, the trained Random Forest model identifies RETPs from listed companies' patents, with data log-transformed for RETI measurement.

- **Models:** Fixed Effects Model

Conclusions

- Based on a sample of Chinese listed companies from 2012 to 2022, the empirical results reveal that RETI effectively reduces corporate ESG greenwashing behavior. Furthermore, the findings indicate that increased board experiential diversity and media attention are associated with a more pronounced negative impact of RETI on corporate ESG greenwashing. These insights provide a systematic framework for the sustainable development of firms in emerging economies and enhance the transparency of corporate information.



Graphical abstract

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