Pollution Prevention or Green Innovation? Unraveling Firms' Environmental Choices

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Abstract

I compare two key corporate environmental actions: (i) source reduction, which refers to process and operational changes to prevent pollution at its origin, and (ii) green patents, which capture environmental innovations with exclusive rights. While the literature has evolved on each of these responses separately, their interaction remains underexplored. Using data from S&P Compustat, the EPA TRI, and supplemental sources from 2001–2020, and employing dynamic panel and instrumental variables regressions, I document systematic substitution between these actions at the firm level. Patenting firms tend to have larger asset bases, are more capital-intensive, hold greater cash reserves, and operate in less-concentrated industries, while firms focusing on source reduction are more emission-intensive and subject to closer regulatory scrutiny. I then examine the motivations for this substitution and whether the two actions deliver distinct returns. Both reduce emissions, but their broader payoffs diverge: green patents bring regulatory relief, greater visibility reflected in higher ESG ratings, rising markups, and overall stronger firm valuation. Source reduction, by contrast, yields gains only on the environmental side: decreasing both the level of emissions and risk-weighted emissions significantly. The findings suggest that firms' environmental portfolios are shaped by differential economic returns and external visibility rather than purely by environmental effectiveness. Future work can refine the analysis by incorporating quality and value-adjusted measures of green patents to better capture heterogeneity in innovation outcomes.

JEL Codes: L20, L50, O14, O31, O34
Keywords: Source reduction, green patents, markup, ESG, regulation, market value

1 Introduction

Amid growing climate activism and investor scrutiny, firms face increasing pressure to demonstrate environmental responsibility. In response, they adopt various forms of environmental

action. Two in particular, green innovation through patenting and process-based source reduction, have received sustained attention.[1] Yet much of the literature examines these actions separately, focusing on questions such as whether regulation induces green innovation or what economic returns green patents generate.

Despite these insights, we still lack a unified understanding of how these actions fit into firms' strategies. If substitution exists between them, it implies purposeful allocation of effort among distinct environmental responses. Such trade-offs reveal whether firms innovate for environmental impact or strategic visibility. Why do some firms rely on patent-based innovation while others emphasize less visible process improvements? How do regulation, market rewards, and firm characteristics shape these responses?

This paper investigates these questions using a unified empirical framework that connects firm-level financial data with detailed measures of source reduction and green patenting. Source reduction, reported in the EPA's Pollution Prevention (P2) database, represents operational changes that prevent emissions. Green patents are identified using the OECD environmental technology classification applied to Kogan et al. (2017) patent data. These are linked with S&P Compustat, EPA TRI emissions, enforcement data from the ECHO database, and ESG ratings from Refinitiv.

Contribution This paper unifies the literature on firms' voluntary environmental actions by examining how the two most studied forms: pollution prevention and green patenting, interact within firms' environmental management portfolios. Rather than asking the conventional questions of how regulation induces voluntary behavior or whether voluntary abatement affects regulatory outcomes, this paper focuses on what firm characteristics drive the choice between these actions and how their economic and environmental payoffs differ under such substitution. By analyzing both strategies jointly, the paper reveals how internal capabilities, market visibility, and regulatory exposure shape firms' incentives to pursue process-based or innovation-based abatement—and how these strategic differences translate into emissions, enforcement, and valuation outcomes.

2 Empirical Design

I assume that firms face implicit emission constraints, as poor environmental performance creates intangible liabilities in the market (Konar and Cohen, 2001). Given these constraints, firms choose among alternative environmental actions. I begin by contrasting firm charac-

[1] See, for example, Sarkis and Cordeiro (2001); Chang and Sam (2015); Carrión-Flores and Innes (2010); Albertini (2013).

teristics using descriptive statistics and multinomial logit models that explain the likelihood of adopting each action. To test for substitution between pollution prevention and green patenting, I estimate instrumental-variable Poisson regressions in which the dependent variable is the count of source-reduction measures, and lagged green patents serve as the main explanatory variable. To address potential endogeneity, I construct two instruments:

- **Shift–share instrument:** pre-sample firm capacity in patenting or source reduction (1991–2000) interacted with contemporaneous trends in its state–industry cell.
- **Peer-exposure instrument:** contemporaneous environmental activity among other firms in the same state–industry, excluding the focal firm.

For outcome analyses, I use dynamic panel estimators and high-dimensional fixed effects regressions to assess the effects of each environmental action on emissions, ESG ratings, markups, enforcement probability, and firm valuation.

3 Main Findings

Firms focusing on patenting differ markedly from those emphasizing source reduction. Patent-oriented firms tend to be larger, more capital-intensive, and less emission-intensive, whereas source-reduction firms operate under tighter regulatory scrutiny.

The results reveal clear substitution: each additional green patent is associated with roughly a 1% decline in source-reduction activities. Both actions contribute to emission reductions, but the impact of green patents is weaker when source reduction is also present. Their broader effects, however, diverge sharply. Within industry groups, green patents yield higher ESG ratings, lower enforcement risk, and higher market capitalization—reflecting their visibility and codified nature. Firms also enjoy greater market power, as indicated by rising markups over time.

By contrast, source reduction delivers more immediate and effective cuts in both level and toxicity-weighted emissions but brings limited recognition in financial or regulatory domains. Perhaps because such actions signal regulatory pressure rather than voluntary innovation, hence, leading to lower market capitalization and Tobin's Q over time.

Overall, the evidence suggests that environmental policy and market forces jointly shape firms' strategic choices: patenting is rewarded through visibility and valuation gains, while process-based pollution prevention remains an undervalued public good, a lever pulled mainly under regulatory pressure.

Acknowledgements and Disclosure Statement

This research has received no external funding. The author declares no financial relationships or potential conflicts of interest related to this research. All opinions and interpretations are solely those of the author and do not necessarily represent those of any affiliated institution.

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