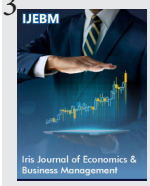

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Mini Review

Green Research Cooperation Under Adaptive Environmental Policy

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Abstract

Cooperation in green research and development (R&D) can facilitate knowledge sharing, but its effects on emissions and welfare depend on regulatory timing, spillover mechanisms, and product-market competition. This mini review synthesizes selected theoretical studies to identify the conditions under which collaborative green R&D merits policy support. It distinguishes R&D expenditure from effective abatement and lower emissions intensity from lower aggregate emissions. The evidence supports joint environmental and competition assessment, explicit rules for policy revision, and separate reporting of innovation, abatement, output, emissions, consumer surplus, and welfare. Because the evidence is mainly theoretical, these implications require empirical validation across industries.

Keywords: Green innovation; research cooperation; knowledge spillovers; environmental policy; competition

JEL classification: L13; L24; O32; Q55; Q58

Introduction

Green R&D involves two market failures: firms capture only part of the knowledge benefits their research creates, while pollution imposes external costs. Research cooperation may mitigate underinvestment caused by knowledge spillovers, whereas environmental policy alters the private return to abatement [1]. Their interaction is especially important in concentrated industries. This selective narrative review examines theoretical studies of research organization, knowledge spillovers, and policy timing. It asks when cooperation warrants policy support and argues that environmental and market outcomes should be evaluated jointly.

Discussion

Research organization and spillovers

Coordinating R&D expenditure and sharing research results are distinct choices. Firms may coordinate R&D while continuing to compete in the product market [2]. A research joint venture therefore differs from a merger, and coordinated research need not entail complete knowledge sharing. These distinctions matter because alternative agreements change both investment incentives and the diffusion of abatement technologies.

Cooperation does not always improve welfare. In a Cournot duopoly in which the regulator sets the emission tax after firms invest in R&D, Ouchida and Goto show that independent environmental R&D can generate higher welfare than coordinated R&D with full information sharing when environmental damage is severe and R&D costs are sufficiently low [3]. This result defines a specific limit to the case for cooperation; it does not imply that independent R&D is generally superior.

Spillover mechanisms also affect the comparison. Input spillovers operate through the resources devoted to pollution

reduction, whereas output spillovers operate through realized abatement. McDonald and Poyago-Theotoky show that, under optimal emission taxation, the input-spillover specification can generate both higher R&D expenditure and higher aggregate emissions than the output-spillover specification [4]. Wang and Atallah find that R&D efficiency and the magnitude and asymmetry of knowledge spillovers affect welfare rankings, including the performance of a joint venture with symmetric contributions [5]. Pooled expenditure and nominal participation therefore provide incomplete measures of environmental performance.

Regulatory timing and instrument choice

When firms invest before the regulator sets an emission tax, they anticipate how abatement will affect the later tax burden; a tax set in advance removes this strategic response [1]. Wang and Li extend the analysis to differentiated products under quantity and price competition, showing that assessments of policy timing and R&D organization depend on the competitive setting [6]. Commitment is not always superior. Puller shows that regulatory discretion may induce oligopolistic firms to innovate so that tighter standards raise rivals' compliance costs, which can partly offset the conventional ratchet effect [7]. Brunner et al. likewise describe a trade-off between investment certainty and the flexibility to incorporate new information [8].

Policy instruments may also yield different environmental and consumer outcomes. In a Cournot duopoly with precommitted regulation, Cabon-Dhersin and Raffin find that cooperative R&D under an emission tax produces more innovation, consumer surplus, and welfare than cooperation under an emission standard. The standard nevertheless produces lower emissions because it reduces output [9]. Lower aggregate emissions can therefore reflect market contraction rather than better abatement technology. Evaluations should report abatement, aggregate emissions, output, consumer surplus, and total welfare separately.

Implications for assessment and management

These findings support comparing each proposed agreement with independent R&D under the same policy instrument and timing, while allowing the regulator to reoptimize policy when the institutional regime permits. Assessments should specify what knowledge will be shared, with whom, and under what conditions, and should track incremental abatement together with output, prices, and R&D costs. Participation incentives also matter: Wang and Atallah show that the stability of partial R&D cartels in a triopoly varies with knowledge spillovers and regulatory timing [10]. Agreements should therefore define knowledge access, cost sharing, and exit rights. Environmental and competition authorities should review these provisions jointly and state the evidence that would trigger policy revision.

Most evidence reviewed here is theoretical and rests on stylized assumptions about market structure, technology, and policy timing. It identifies mechanisms and conditional rankings, not transferable effect sizes or an empirically validated approval rule. Empirical research should test whether observed cooperation produces additional abatement after accounting for changes in output, knowledge diffusion, and regulatory responses.

Conclusion

Policy support for green R&D cooperation should require credible evidence of additional environmental benefits and an assessment of the resulting welfare trade-offs. A credible policy regime should combine predictable incentives with transparent revision procedures. Evaluation should distinguish R&D expenditure, technological improvement, abatement, output, emissions, consumer surplus, and welfare. These distinctions allow conditional theoretical results to inform regulatory and managerial decisions without treating cooperation as inherently beneficial.

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Declaration of Interest Statement

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