



The two Coases of green governance: multinational enterprises and the internalization of environmental externalities through green innovation

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Abstract

Green governance aims to resolve environmental externalities at minimum cost. By uniting Coase's two foundational theories (Economica 4: 386–405, 1937; J Law Econ 3: 1–44, 1960) we reframe MNEs not merely as profit-seeking entities but as transnational institutions capable of internalizing environmental externalities through green innovation across borders. We show how national environmental regulation spurs subsidiary-level green patenting with profit spillovers into third-country markets, thereby yielding environmental benefits. Using data on over 1.4 million MNE-owned green patents (including 10,444 patents from 103 foreign subsidiaries of 89 MNEs, 1998–2014), we examine how host-country environmental regulatory stringency shapes subsidiary innovation. We find that a higher national mix of market-based over non-market regulatory stringency significantly increases local subsidiaries' green patenting, and that green patenting in one jurisdiction enhances parent MNEs' net profits in third-country markets. These effects suggest MNEs can operate as low-cost institutional engines of the Green Agenda by diffusing green innovation, complementing fragmented international governance efforts. They also imply that large economies can exercise policy leadership by prioritizing market-based regulation design that induces green innovation with cross-border benefits. Our Coasean approach to global environmental governance highlights MNEs' promise for addressing grand challenges, particularly in extending the reach of the Green Agenda and in realizing the Sustainable Development Goals.

Keywords Green innovation · Green governance · MNE subsidiaries · Green patents · Sustainable development

Introduction

The private sector must be a key driver for sustainable development, including leadership of technological transformations ... essential for sustainable development. Profits must be the reward for contributions to the common good, not private gains achieved at the public's expense.

“—UN Sustainable Development Report 2024”

The Green Agenda represents the world's most ambitious effort to reconcile economic growth with ecological sustainability. It is a constellation of ideas, regulatory developments, and initiatives spanning from early environmental legislation in the 1950s to contemporary frameworks such as the Paris Agreement and Agenda 2030. Environmental mandates have been, over time, incorporated into national constitutions, development plans, and international accords, culminating in the Sustainable Development Goals (SDGs)¹. Despite this proliferation of regulatory sophistication, global emissions and ecological degradation continue to rise while environmental governance remains fragmented across jurisdictions (Romanello, Walawender, Hsu,

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¹ Key milestones include the Clean Air Acts in the United States (1955), the United Kingdom (1956), China's constitutional and policy reforms on sustainable development (State Council Information Office of the People's Republic of China, 2006), the Brundtland Commission's Our Common Future (1987), the MDGs, SDGs, the Paris Agreement, and Agenda 2030, coinciding with firm internationalization, a growing role for MNEs (e.g., Kolk & Pinkse, 2008), and rising regulatory stringency.



Moskeland, Palmeiro-Silva, & Scamman, 2025), producing uneven incentives for technological transformation (Botta & Kozluk, 2014). The central problem – how to coordinate effective global environmental action under publicly divergent national interests – remains unresolved. At the same time, within the private sector, multinational enterprises (MNEs) sit at the heart of the sustainability governance challenge; they are both contributors to environmental harm and important agents of its mitigation (Kolk & Pinkse, 2008; Nippa, Patnaik, & Taussig, 2021). This dual role makes the mobilization of MNEs politically important and analytically motivating (Brundtland Commission, 1987; Cuervo-Cazurra, George, Santangelo, Tihanyi, Xufei Ma, Senbet, & Doh, 2026; Zhan & Santos-Paulino, 2021).

Where public meets private is in the area of regulation and the Green Agenda. Neoclassical economics has long approached the governance of environmental externalities through Pigouvian intervention – state-led correction of market failures via taxes, subsidies, and regulation (Pigou, 1920). Pigouvian instruments, such as carbon pricing and emission standards, remain foundational to most environmental regulatory architectures (Goulder & Parry, 2008). Notably, stringency is enacted through market-based and non-market instruments that can differ in their innovation impacts (Jaffe, Newell, & Stavins, 2002). A large amount of literature further suggests that regulation can redirect innovation by shifting relative prices and constraints; with induced innovation (Hicks, 1932), stricter regulation raises the implicit price of pollution and reorients inventive effort towards cleaner technologies (Popp, 2002). The Porter hypothesis (Porter & van der Linde, 1995) adds that well-designed regulation can induce innovations that partly or more-than-fully offset compliance costs, particularly when rules are outcome-based and predictable. With green regulation shifting the direction of innovation, green technologies and patents are frequently developed, recombined, and commercialized through multinational networks, including MNE subsidiaries (Papanastassiou, Pearce, & Zanfei, 2020).

Environmental regulation is typically designed and evaluated with primarily domestic effects in view (Jaffe et al., 2002). The international reach of green regulation has been constrained by political fragmentation and the global free-rider problem (Bounds, 2024; Keohane & Victor, 2016). Nordhaus (2015) proposes the “climate club” – coalitions of willing states that coordinate carbon pricing and penalize outsiders, but this solution has been criticized for high international public negotiation and enforcement costs (Falkner, Nasiritousi, & Reischl, 2022). The puzzle then is how effective international environmental coordination can occur in a world where Pigouvian regulation is nationally bounded, climate clubs are costly to form, environmental externalities are global, and firms organize internal markets in which

operating units can negotiate with each other to outperform external markets.

We propose a novel theoretical approach – a Coasean reframing of cross-border environmental coordination, given the context of high intergovernmental bargaining costs. Coase (1937) explains why firms arise to replace inefficient external markets by internal markets – and create internal markets when external markets are missing. Coase (1960) – a foundational study that sets out the basis for legal principles to resolve externalities – argues how private coordination can, in principle, address externalities when the frictions of bargaining and enforcement are low. Understandably enough, this seminal paper did not explore the full possibilities of innovation in production conditions. However, if we introduce innovation into this bargaining framework, we have the germ of how proprietary innovation, induced using Pigouvian logic, may translate into the domain of the corporation, specifically the MNE. The private bargaining mechanism finds its natural home within the internal market (Coase, 1937) while proprietary technology holds the potential to ameliorate the problem of external social cost as expressed by Coase (1960). Our aim is to integrate Coase’s two contributions using the common thread of induced innovation. Our challenge is that global environmental externalities are costly to govern through intergovernmental bargaining alone. However, we know that MNEs can internalize cross-border transactions and enforcement through internal market and private coordination. Our theoretical motivation is therefore that we stand in need of theory (and evidence) on how MNE internalization of green technology may function as a low-transaction-cost complement to Pigouvian-type regulation.

To address this theoretical gap, we ask: *By what mechanisms might MNEs address environmental externalities through green innovation and how can the domestic benefits of national environmental regulatory stringency be deployed within the MNE to third markets?* By green innovation, we mean the development and subsequent commercialization of technologies that improve environmental performance across products and processes (e.g., Ellimäki, Aguilera, Hurtado-Torres, & Aragón-Correa, 2023). “Green stringency” refers to the degree to which environmental regulations “address wellbeing and sustainability objectives [by] affecting firm and household behavior” (Albrizio et al., 2014). In this study, green stringency captures a range of instruments, broadly classified into market-based (e.g., carbon pricing and tradable permits) and non-market (e.g., standards and mandates) instruments. We develop a Coasean institutional framework that integrates the top-down Pigouvian rationale of state-led corrective incentives with the bottom-up Coasean rationale of private bargaining to overcome externalities. Thus, governments provide regulatory signals that correct environmental prices and reshape

incentives and constraints domestically, which induce green innovation for mitigating local environmental harm. At this point, commercial reality breaks with the existing theory of how IB can contribute to the Green Agenda. By their nature, MNEs are drawn to deploy their induced proprietary green technologies through international internal R&D networks and global value chains, leading to third-market profit gains. Hence, MNEs can extend some benefits of domestic regulation beyond national borders through intra-firm coordination. If so, firm-governed networks may more efficiently realize the coordination effects that Nordhaus's (2015) climate club seeks, though burdened by costly intergovernmental negotiation.

We test this framework empirically through a two-stage investigation. Stage 1 examines local effects of environmental stringency on subsidiary green patenting, distinguishing between the effects of market-based and non-market instruments. Stage 2 investigates cross-border effects by assessing whether green patents generated under local regulatory pressure enhance parent MNEs' profits in third-country markets. The analysis draws on over 1.4 million MNE-owned green patents, including 10,444 patents from 103 foreign subsidiaries of 89 MNEs during 1998–2014.

Our contribution begins by integrating Coase's two seminal theories through the latent common thread of innovation, specifically policy-induced green innovation. We show how the “two Coases” can be better appreciated as facets of a deeper theory that coalesces when technology changes, seeking the most efficient and extensive social canvas on which to work. We explain how host-country environmental regulation, through prompting local subsidiary-level green patenting, may go on to yield profits in third-country markets. These profit spillovers signify beneficial environmental policy spillovers through MNEs' sister subsidiaries following their own, and parental, profit motive in exploiting green innovation. That market-based instruments of regulatory stringency exert greater effect than non-market instruments is consistent with prior research on these price-like incentives' natural affinity with profit and is particularly instructive for inducing green innovation at home and beyond. Given the absence of a top-down global or multi-lateral institutional framework within which to pursue the Green Agenda and the Sustainable Development Goals, the MNE emerges from our analysis as offering great potential to address these grand challenges. Our contribution provides a rationale for International Business (IB) research to be regarded as holding perhaps the greatest promise, through harnessing the private sector, to answer the most vexed questions of global environmental governance.

Theoretical foundation

Two Coasean theories

In *The Nature of the Firm*, Coase (1937) advanced an explanation of why firms exist in market economies that, in theory, should be perfectly coordinated by prices alone. He argued that the price mechanism itself is costly to use, as discovering relevant prices, negotiating contracts and monitoring performance all generate what he termed “the cost of using the price mechanism” (p. 390). When these transaction costs become substantial, coordinating activity through internal organization can be more efficient than relying on external market exchange. Thus, firms arise as institutional arrangements that economize on transaction costs, with their boundaries determined by the relative efficiency of internal versus external coordination. Later developments extend this reasoning to the international dimension, explaining how MNEs internalize the markets for cross-border transactions when markets for intermediate products, technologies, or knowledge are inefficient, incomplete, or absent (Buckley & Casson, 1976).

In *The Problem of Social Cost*, Coase (1960) reframed externalities by arguing that problems such as pollution are reciprocal in nature: preventing harm to one party necessarily imposes costs on another. Coase demonstrated that, if property rights are clearly defined and transaction costs are low enough, private bargaining among affected parties can, in principle, yield efficient outcomes without reliance on government intervention à la Pigou. This is commonly referred to as the Coase theorem. However, we know that real-world transaction costs, such as those arising from negotiation, information asymmetries, or enforcement frictions, especially where multiple actors and jurisdictions are involved, are substantial. Consequently, national public institutional mechanisms or organizational forms are routinely created by governments to mediate exchange and intervene. The governance of externalities is a matter of institutional choice.

While Coase (1937) is argued at the level of the private firm, or legal individual, Coase (1960) is focused on setting out an argument at the level of the natural individual. As Coase (1937) explained, private firms rise to the challenges of external market inefficiency (disputes and property rights enforcement included) by creating internal markets to overcome these impediments. Thus, the firms' distinctive ability to overcome barriers through organizational means (as opposed to negotiations between natural individuals within markets) is a foundation provided by Coase (1937), upon which Coase (1960) can be layered, ultimately to address external social cost through the mechanism of the private firm. Moreover, while natural individuals cannot extend



themselves across borders, legal individuals (firms) can operate in multiple locations. In this sense, Coase (1937) provides a conceptual approach for understanding how spatially networked organizations such as MNEs might act as transnational institutions that reduce the transaction costs of negotiating, transferring, and working green technologies across borders to reduce environmental harm. Coase (1960) can, in turn, be harnessed to show how firms may provide a private solution to resolve external social costs of both an international and reciprocal nature, potentially substituting within-the-firm negotiation and resource reallocation for multiple state-imposed regulations or costly international treaties, or both. The only limit to this capacity is the extent of the firm's economic reach – between subsidiaries, affiliates, and value-chain partners dispersed across jurisdictions. The Coasean rationale of recruiting private firms, here MNEs, offers a theoretical bridge between the governance of the firm and the governance of the environment.

Pigouvian intervention and environmental regulation

Pigou's (1920) case for government intervention starts with a diagnosis: in competitive settings the marginal private net product that motivates firms and households typically diverges from the marginal social net product that matters for welfare. When actions spill over onto others – beneficially (e.g., research, parks, and lighthouses) or harmfully (e.g., smoke, road wear, and amenity loss) – market prices fail to signal full social costs and benefits, so laissez-faire allocations will not maximize the “national dividend”. His remedy is to correct at source in a top-down manner with targeted instruments: taxes, where private returns exceed social returns (negative externalities) and subsidies, where social returns exceed private returns (positive externalities), calibrated so that industries produce the “ideal” output at which marginal social net products are equalized across uses. In distributional terms, because of diminishing marginal utility, Pigou (1920) also argues there is a welfare case for transfers towards “the relatively poor” provided they do not shrink the national dividend.

At the same time, Pigou (1920) is not naïve about state capacity. Pigou conceives government action chiefly as a toolkit steering private initiative towards the social optimum while leaving it largely in private hands. In practice, this control mixes calibrated taxes and subsidies (to realign private and social net products) with standards (e.g., price regulation, quality thresholds, licensing, and inspection) and disclosure (to deter evasive degradation of outputs). Because any single instrument is leaky and costly to supervise, Pigou's (1920) preferred stance is hybridization – combining fiscal instruments with regulatory oversight so that price, quantity, and quality margins are addressed. Furthermore,

because people exhibit a present-bias (Pigou's famous “telescopic faculty”), private choices underweight the future, implying an additional rationale for interventions that protect long-horizon investments and public goods.

In the narrow, textbook sense, environmental regulations are Pigouvian when they exert pressure to create internal markets for externalities so that private decision-makers face the full marginal social costs and benefits of their actions. Typical instruments of this nature are emissions taxes and subsidies (“bounties”) for activities with positive spillovers (e.g., clean-tech R&D). Tradable permits are Pigouvian in effect: if the cap is set at the welfare-maximizing quantity, the resulting permit price mirrors the Pigouvian tax that would achieve the same outcome, though under uncertainty, prices and quantities differ in performance (Pigou, 1920).

In practice, modern environmental regulation is a hybrid. Standards, bans, and technology mandates are Pigouvian in spirit, in the sense that these are forms of state control used where prices alone are leaky or hard to implement (Pigou, 1920). Moreover, with pre-existing distortionary taxes and distinct knowledge spillovers in innovation, a single Pigouvian price is usually second-best. The welfare-maximizing arrangement therefore bundles various instruments: pricing (to steer the direction of change) accompanies R&D support and, where needed, performance or technology standards are added to raise the level of inventive effort and overcome lock-in (Goulder & Parry, 2008; Jaffe et al., 2002). While Coase (1960) reminds us that well-defined property rights with negligible transaction costs might substitute for taxes, large-scale environmental problems typically involve high bargaining frictions, making Pigouvian-style regulation the workhorse of governance frameworks.

In view of the global nature of environmental externalities, conceptual solutions have been proposed, however these remain costly. For example, climate clubs (Nordhaus, 2015) aim to overcome free riding by pairing a common minimum carbon price with border penalties on non-members so that participation becomes privately optimal. In theory, this converts a diffuse public-good into a club-good with excludable benefits; in practice, high negotiation and enforcement costs, legal uncertainty around border adjustments, and equity disputes make perfectly coordinated clubs fragile and administratively heavy (Keohane & Victor, 2016). In pragmatic terms, while Pigouvian-style regulatory packages (pricing plus complementary standards and R&D support) remain the domestic governmental first port-of-call, in the international domain, hankering after a first-best, globally harmonized regulatory club-like arrangement is unlikely to be cost-effective.

We argue that a Coasean reframing of costly intergovernmental interventions can reveal a lower-cost institutional pathway that leverages border-crossing private organizations such as MNEs as coordination nodes in the global



environmental governance regime. When intergovernmental bargaining faces prohibitive transaction costs, the internal organization of the firm (Coase, 1937) utilizing private arrangements structured through contracts and property rights (Coase, 1960) offers clear promise to address market failure, bringing the resolution of reciprocal cross-border externalities within the scope of the firm. For example, MNEs can embed internal carbon prices, green procurement standards, supplier licensing and inspection clauses, technology sharing agreements, and IP pools within their global value chains (e.g., Desjardins & Sinclair-Desgagné, 2025). These instruments transform market access, preferred supplier status, and reputational capital into excludable “club benefits”. Such mechanisms shift some enforcement functions from treaty diplomacy to supply-chain governance, reduce the dimensionality of negotiations (bilateral contracting rather than universal agreement), and amplify domestic or internationally agreed Pigouvian signals by expanding the effective market for green technologies within MNE ecosystems. Evidence remains emergent, but the mechanism is theoretically coherent: private governance can amplify demand-pull effects and lower transaction costs where public coordination is hardest, functioning as a second-best, low-cost complement to national pricing, standards, and public R&D investments (Gereffi, Humphrey, & Sturgeon, 2005).

Induced green innovation and MNEs

Environmental regulations have been found to both directly and indirectly stimulate green technology development (e.g., Popp, 2002). Hicks (1932) suggested that changes in relative input prices incentivize firms’ innovation to economize on more costly factors. Applying the induced-innovation rationale to the environment, the Induced Green Innovation (IGI) hypothesis posits that stringent regulations raise the implicit price of pollution, thereby redirecting firms’ inventive efforts toward greener technologies (Popp, 2002). While IGI predicts the rate and direction of technological change, it does not necessarily imply improvement in firm productivity or profit. The latter, stronger proposition (that well-designed environmental regulation can enhance both innovation and competitiveness) is articulated in the Porter hypothesis (Porter & van der Linde, 1995). It posits that environmental regulation can induce innovation that raises resource productivity, generating “innovation offsets” that can partly or even more-than-fully compensate compliance costs (weak versus strong versions of the hypothesis), with the greatest gains when rules are outcome-based and predictable. Larger market size or fast-growing markets can amplify the regulatory effect (Porter & van der Linde, 1995).

From an IB perspective, MNEs can aggregate demand across jurisdictions, reduce transaction costs arising from fragmented regulation or weak IP enforcement, and redeploy

green technologies across subsidiaries – amplifying the market-size and coordination effects emphasized by IGI and the Porter hypothesis. In Coasean terms, the firm substitutes private arrangements (e.g., intra-firm transfer prices/internal carbon pricing, supplier standards and audits, licensing, and patent pools) for costly intergovernmental bargaining. Thus, by extension from Coase (1937, 1960) MNEs have the capacity to address reciprocal cross-border externalities through the creation and expansion of internal markets internationally. In this way, the benefits of the provision of property rights enabling green patenting, licensing and technology transfer within MNE networks become not a direct substitute for national public regulation but a complement, offering a lower transaction cost mechanism that scales up domestic demand-pull effects across borders, while remaining anchored in formal regulation.

A Coasean institutional framework for transnational green governance and innovation

We develop a Coasean institutional framework in which national environmental regulation supplies Pigouvian-type price signals and corrective incentives that induce green innovation locally, while MNEs, through internal markets and globally distributed R&D networks, diffuse these induced solutions across borders. When a green technological innovation is generated in a jurisdiction with stringent environmental regulation, non-deployment in other jurisdictions creates an opportunity cost to the MNE in the form of rents foregone from not profitably redeploying that knowledge across the firm’s network. Equally, in the MNE’s third-country markets, subsidiaries face the opportunity cost of profits forgone by not applying novel green technologies, so triggering the external social opportunity cost of not reducing environmental harm. Therefore, Coase’s (1960) principle that environmental externalities represent reciprocal conflicts over alternative resource uses is conformable at the level of the firm and internationally, specifically, when legally distinct subsidiaries within the MNE face choices that affect the total product of the firm, and indirectly, total social product. The problem in question is of an international (or global) reciprocal nature, i.e., whether MNEs can internally reallocate and deploy the innovation induced locally by national regulation in ways that raise profits while extending environmental benefits across borders. The profit motives of the innovating and technology-using subsidiaries, and the MNE, thus offer a private solution that carries with it wider welfare gains. Rather than leaving such redeployment to arm’s-length exchange, the MNE can coordinate the transfer and use of green innovation within its own network, allowing profit-seeking decisions in third-country markets to be



traced back to the environmental stringency that promoted innovation in the initial host market. We next elaborate on the managerial and organizational mechanisms underpinning these local and cross-border effects.

Local effects

National environmental stringency operates as a hard incentive to innovate (Hicks, 1932; Popp, 2002), particularly in jurisdictions at the forefront of the Green Agenda. For foreign subsidiaries, however, local inducement is rarely a purely local process. The knowledge-based view (Kogut & Zander, 1993) highlights how MNEs can transfer and recombine knowledge and capabilities within internal networks, reducing market imperfections that impede market-based exchanges of intangible assets between independent firms (Dunning, 2015). Within the MNE, subsidiaries may be expressly mandated to create or adapt innovation by combining host-country resources – such as talent (Cantwell & Mudambi, 2005) and embedded local knowledge (Kafourous, Buckley, & Clegg, 2012) – with parent firms' global networks to develop, commercialize, and diffuse technologies across borders. In the context of green innovation, these internal networks can endow subsidiaries with an “advantage of foreignness” in green innovation relative to domestic firms (De Marchi, Cainelli, & Grandinetti, 2022). They can also reduce the risk of subsidiaries responding myopically to local regulation, e.g., links with customers, suppliers, and sister units provide access to cross-border market intelligence and technological developments (West, Salter, Vanhaverbeke, & Chesbrough, 2014).

Cross-border effects

Because MNE subsidiaries are nodes within an internalized organizational system, locally induced green technologies can be redeployed and commercialized across the MNE's multinational footprint rather than remaining confined to the originating host context (Dunning, 2015; Kogut & Zander, 1993). Internal technology markets (Birkinshaw & Hood, 1998), especially those embedded in MNE-led value chains (Dong, Tan, Wang, Zheng, & Hu, 2021), can operationalize global demand by enabling subsidiaries to access, absorb, and apply green technologies produced elsewhere. While subsidiaries adapt to host contexts, parent MNEs ultimately exert coordination and control (Dunning, 2015) to ensure that technologies developed by subsidiaries resonate across the MNE's portfolio of geographic markets (Berry, 2014). Innovative upstream subsidiaries can coordinate with downstream ones (Rugman, Verbeke, & Yuan, 2011), forming intra-firm value chains that enable green technologies to be adopted and worked in third-country markets (Gereffi et al., 2005). We can infer that induced innovations generated

in stringent jurisdictions may yield non-local value when internal governance makes cross-border diffusion feasible and privately worthwhile, with benefits materializing in third markets through productivity, revenue, and profit gains (Dechezleprêtre, Glachant, & Ménière, 2021). In an external market context, the classical “epidemic model” of technology diffusion (Griliches, 1957) has long maintained that higher adoption rates reduce perceived risk for later adopters (Mansfield, 1968). By extension to the internal market of MNEs, such an amplification effect can also be expected between subsidiaries as reduced information asymmetry is supportive proof of efficacy (Driffield, Love, & Menghinello, 2010).

Hypotheses development

Local effects of market-based green stringency on green innovation

Environmental regulation can induce innovation by altering the relative returns to existing production routines and alternative technological responses (Jaffe et al., 2002). In our Coasean framework, the central issue is not regulation per se, but how regulatory design reshapes the opportunity cost of non-innovation. Market-based instruments such as carbon pricing, tradable permits, and feed-in tariffs create continuous marginal incentives for firms to reduce emissions and improve environmental performance (Albrizio et al., 2014; Johnstone, Haščič, & Popp, 2010). By changing the relative prices attached to polluting and cleaner activities, such instruments raise the opportunity cost of maintaining existing technologies and expand the set of privately profitable green innovation initiatives. Firms that can devise lower-cost abatement methods, cleaner processes, or more environmentally efficient products are not only better able to comply but may also capture rents accordingly (Jaffe et al., 2002). This inducement should be especially strong where relocation is costly or where the regulated market is sufficiently important to justify adaptation over mitigation. This has been shown empirically in the effects of emission taxation on firm responses moderated by relocation costs and market conditions (e.g., Birg & Voßwinkel, 2021).

In contrast, non-market instruments, such as command-and-control measures, technology mandates, and discrete compliance standards, often operate through prescribed thresholds or required practices rather than continuous price-based inducements (Czarnitzki & Lopes-Bento, 2020). Although such instruments may stimulate innovation under some conditions, they more often channel firms towards narrower compliance responses and provide weaker incentives for ongoing experimentation across a wider range of technological options. Evidence on some non-market instruments,



particularly R&D subsidies, suggests limited additionality in that they may partly substitute for innovation expenditures that firms would have undertaken anyway (Marino, Lhuillery, Parrotta, & Sala, 2016; Popp, 2002). Across jurisdictions, benefits may be especially limited where subsidy-induced innovation is not strongly reinforced by continuing market incentives, reducing the scope for broader crowd-in effects for both domestic and foreign firms (Czarnitzki & Lopes-Bento, 2020).

This market-versus-non-market distinction is particularly important for MNE subsidiaries because host-country regulatory effects are filtered through comparative governance and intra-firm organization. In Coasean terms, the MNE's internal organization can reduce the transaction costs of identifying, adapting, and safeguarding knowledge-intensive responses to regulation (Coase, 1937; Dunning, 2015). The domestic regulatory stance of market to non-market stringency signifies to the firm the extent to which continuous price signals are prioritized over compliance signals. This shapes innovation incentives and investment decisions. Because MNEs operate across jurisdictions, subsidiary innovation is often coordinated by headquarters not only in response to local regulatory design (Marin & Zanfei, 2019) but also in light of inter-jurisdictional differences in the character of regulatory stringency (e.g., Jackson & Deeg, 2008). Market-based regulation is more powerful and predictable than non-market. When greater in the regulatory mix, the expected payoff from innovation rises (Nippa et al., 2021), thus increasing the incentive subsidiaries in high-stringency jurisdictions. Accordingly, we expect regulation exhibiting a stronger market rather than non-market signature to exert a more forceful inducement effect on subsidiary green innovation.

Hypothesis 1: Market-based green stringency will exert a stronger direct effect compared with non-market green stringency on the green innovation output of MNE subsidiaries.

Cross-border effects of green innovation on third-market profits

A central implication of our framework is that, once green innovation is induced in a stringent host country, the MNE faces a choice over alternative internal uses of that technology. Non-deployment in third-country subsidiaries entails an opportunity cost in the form of foregone profits. Unlike arm's-length diffusion through external markets, which may be impeded by contracting costs, information asymmetries, and imperfect appropriability (Teece, 1986), internal organization eases the way for MNEs to economize on transaction costs in coordinating the transfer, adaptation, and deployment of proprietary technologies across subsidiaries (Birkinshaw & Hood, 1998; Rugman et al., 2011). Thus,

the use of the internal market makes diffusion more likely and profitable.

This lower-cost internal diffusion is economically significant because many green innovations improve resource efficiency, reduce production costs, and enable new product or service offerings, thereby increasing profitability when applied at scale (Berry, Chauvin, Cheng, & Lee, 2025; Rexhäuser & Rammer, 2014). The value-capture logic is strongest when upstream innovation can be aligned with downstream market opportunities across the MNE's value chain, precisely the coordination challenge that internalization is designed to address (Rugman et al., 2011). In this sense, the MNE acts through its private organizational agency to convert locally induced green innovation into profit-generating applications abroad.

Green patents, in particular, often embody proprietary know-how that can improve both environmental performance and commercial outcomes, e.g., through energy-efficiency gains (Rexhäuser & Rammer, 2014), emissions reductions (Nameroff, Garant, & Albert, 2004), water conservation (e.g., Hötte & Jee, 2022), circular production process redesign (Valero-Gil & Scarpellini, 2024), and improved environmental management practices (Wagner, 2007). When employed internally, such technologies create monetizable value through cost savings, productivity gains, and the expansion of market opportunities for greener products and services.

The above reasoning leads to our second hypothesis:

Hypothesis 2: Green innovation by an MNE's subsidiaries in one or more host countries increases the profits of the MNE's subsidiaries in third-country markets.

Methods

The innovation literature recognizes green patents as a widely accepted indicator of substantive green innovation because they capture codified technological advances that entail real investment, commercial intent, and environmental problem-solving (e.g., Haščič & Migotto, 2015). Unlike SDG reporting, which may be largely symbolic (van der Waal & Thijssens, 2021), green patents provide observable evidence of environmental innovation that aligns with UN and OECD frameworks; for example, the OECD Green Growth Indicators aggregate from firm-level green patenting (OECD, 2024), and green technologies map onto 11 of the 17 SDGs (Walz, Pfaff, Marscheider-Weidemann, & Glöser-Chahoud, 2017). We therefore use green patenting as the core measure of firms' contributions to sustainable technological progress.

To test the local and cross-border effects, we employ a two-stage research design. Stage 1 examines whether



host-country environmental stringency (differentiating market-based from non-market stringency design) induces green innovation in foreign-owned subsidiaries (H1). Stage 2 assesses whether green innovation generated in stage 1 produces third-country profit gains for parent MNEs several years later, capturing the diffusion and return of innovation across the MNE network (H2). Dataset construction, inclusion criteria, measures, and models for each stage are outlined below.

Stage 1: Local effects of green stringency

Sample and data

To evaluate the subsidiary-level response to local green stringency, we use a sample of subsidiaries that meet the following *a priori* criteria: (1) foreign-owned: majority-owned (>50%²) by a parent located in a country with available OECD EPS stringency data; (2) commercially active: revenue-generating with ≥ 50 employees and $\geq$ USD 50 m annual revenue; (3) innovation-capable: possess observable patenting activity and full subsidiary-level records for the study period; (4) part of a recognizable MNE with consolidated and traceable ownership structures; and (5) located in host economies with sufficient institutional openness and time depth to support internationalization and innovation.

Subsidiary-level research involving cross-country comparison faces the challenge of a lack of comparable data. To address this, we apply these criteria to the Orbis database – which offers harmonized ownership and firm-level data across countries dating back to 1995. This step yields an initial population of 38,739 majority-owned foreign subsidiaries across 4182 MNEs headquartered in 33 stringency-reporting economies. We next identify green patents for all subsidiaries using Orbis Intellectual Property³ and the OECD Green Patent Classification (Haščič & Migotto, 2015), evaluating 44.9 million patent-inventor records⁴. This process identifies 1,416,607 green patents across ten two-digit OECD green technology categories. To examine subsidiary-level innovation and host-country regulation, each subsidiary is matched to the country-year dataset of OECD Environmental Policy Stringency (EPS) market-based and

non-market stringency scores (Botta & Kozluk, 2014; Kruse et al., 2022). Consistent with the regulatory diffusion literature, we lag stringency measures by (at least) 6 years. After excluding incomplete observations, the final workable sample for stage 1 is a panel data of 943 subsidiary-year observations, covering 103 MNE foreign subsidiaries (with a combined output of 10,444 green patents) owned by 89 MNEs for the period 1998–2014. Table S1 (see online supplementary material) summarizes data sources and variable definitions.

Our final sample covers 14 countries: the USA, Germany, France, Italy, Austria, Japan, Belgium, Switzerland, Finland, Ireland, Norway, the Netherlands, Sweden, and China. These home economies offer several advantages for our investigation. First, they are large economies and close trading partners to each other⁵, with conditions favorable for firm international expansion and competitive innovation. Second, they rank highly in terms of firms' global innovation capabilities (GII, 2014) and outward foreign direct investment (FDI) (e.g., He, Fallon, Khan, Lew, Kim, & Wei, 2017). Third, MNEs from these countries have developed increasingly complex global innovation networks (Papanastassiou et al., 2020). Fourth, these home countries differ in social, economic, and legal attributes, providing useful variations for robust estimations and accounting for diverse home influences on foreign subsidiary behavior (Dunning, 2015).

Measures

Our dependent variable, *Green Patents Count of a Subsidiary*, is the number of green patents owned by a foreign subsidiary in a given year, forwarded by 1 year. Patent count is a commonly used output measure in the innovation literature (e.g., van der Waal et al., 2021). The forwarded measure of patent count reflects the time it may take for the independent variables to exert their influences.

Measurement of our focal independent variables relies on a set of EPS indices provided by the OECD, covering most OECD countries since 1990. The indices are well suited for cross-country comparisons because of their greater coverage and validity as evidenced by their “relatively high and significant correlations with alternative proxies of EPS used in the literature” (Botta & Kozluk, 2014). Based on a taxonomy of regulatory instruments developed by De Serres, Murtin, and Nicoletti (2010), EPS indices are constructed for “Market-based policies” and “Non-market policies” (Botta & Kozluk, 2014). We use these two indices to measure our

² We select subsidiaries with a global ultimate owner, defined by Orbis as an entity that directly or indirectly controls 50% or more of ownership.

³ Orbis Intellectual Property allows us to collect each subsidiary's patents granted by 68 international patent offices, dating back to the earliest patent publication in 1900 and forward to 2025.

⁴ Using OECD Green Patent Classification (Haščič & Migotto, 2015) and the IPC information available within the patent dataset, we follow protocols of OECD (2022) and Wang and Clegg (2026) to evaluate patents and inventors associated with these subsidiaries.

⁵ For example, Germany, France, and Italy are top three countries by share of intra- and extra-EU trade in all products (Eurostat, 2023) and are each other's top trading partners (World Bank, 2023). The USA and China are important trading partners of each other and to the other countries in the sample.



focal variables, Green Stringency: Market-Based, and Green Stringency: Non-market, respectively. See Table S2 (online supplementary material) for a list of instruments in each grouping and relevant descriptive scores. Because it takes time for regulations to exert effects, we lagged all Green Stringency variables by 6 years. We also used different lags to confirm the robustness of our results (see Analyses section).

We include various control variables specific to the parent MNE, the subsidiary, the host country (where the subsidiary operates), and the home country. See Table S1 for details.

Stage 2: Cross-border effects of green stringency

Sample and data

To investigate the cross-border effect of induced green innovation, we construct an MNE-level dataset using subsidiaries located in third markets – host countries other than where the initial green innovation (stage 1) was induced by local green stringency. The focus on third countries aligns with our theorization of MNEs as cross-border conduits of knowledge and innovation: if green innovation has value, we expect it to yield positive returns even in subsidiaries that were not directly exposed to green stringency. We specifically study “non-green-patenting subsidiaries” – subsidiaries that belong to the same parent MNEs identified in stage 1 but that have not generated green patents themselves in the years following the stage 1 period. By focusing on these entities, we can isolate the diffusion and performance effects of green innovation originating elsewhere in the MNE network, rather than local innovation efforts in the third country itself. Stage 2 inclusion criteria: (1) belong to the same MNEs identified in stage 1; (2) non-green-patenting subsidiaries during 2015 onward; (3) profit-generating with available net-profit data to 2024; and (4) located in countries with sufficient longitudinal data coverage.

Applying these criteria, we obtain a dataset of 474 profit-generating subsidiaries operating in 33 third countries, all linked to 40 parent MNEs. These MNEs operate in 29 two-digit industries and originate from 13 home countries: Austria (1), Belgium (3), Switzerland (2), China (1), Germany (3), Finland (2), France (6), Ireland (1), Japan (5), the Netherlands (1), Norway (1), Sweden (4), and USA (10). We then aggregate the subsidiary-level data to form 105 distinct MNE-country dyads. The full observation window covers a period of 30 years (1995 to 2024). Since it may take time for green stringency to induce green innovation, and it will take further time for value appropriation to arise across borders, we examine third-country net profits 4–7 years after MNEs’ green patenting activities (induced in stage 1 by green-host-country stringency). Excluding incomplete observations, the final dataset for stage 2 is an unbalanced panel of 160

distinct MNE-country-year observations during 19 years between 2001 and 2019.

Model and measures

To test hypothesis H2, we estimate the following model of Third-Country Net Profits of the parent MNE m in third country i in year t :

$$\text{Third-Country Net Profits}_{mi(t+4)} = \beta_0 + \beta_1 \text{Green Patents}_{mt} + \Phi(X\beta) + v_{mit} \quad (1)$$

where β_0 is the intercept; β_1 is the corresponding coefficient of green patents of MNE m induced in stage 1 at year t ; v_{mit} is the error term. For simplicity, Φ represents the control variables (X) vector and β the relevant coefficient. In this and subsequent equations, $t+4$ is used as an example to show that profit outcomes occur several years after green innovation.

The dependent variable is measured as the sum of after-tax net profits of subsidiaries of MNE m operating in third country i , observed 4 years after the year t when the green patents were granted:

$$\text{Third-Country Net Profits}_{mi(t+4)} = \sum_{j=1}^{J_{mi(t+4)}} \text{Net Profits}_{jmi(t+4)} \quad (2)$$

where subscript j is the subsidiary that has not generated green patents during the post-stage-1 period (from 2015 onward) and $J_{mi(t+4)}$ is their total count in year $t+4$ in country i . Accordingly, $\text{Net Profits}_{jmi(t+4)}$ is the after-tax net profits of subsidiary j . The forward lag reflects the time needed for green technologies to be incorporated in the income-generating activities of the MNE subsidiaries in a third country, while mitigating reverse causality (i.e., profits leading to innovation investment).

The focal independent variable, Green Patents, is the total number of green patents generated by MNE m in year t through its subsidiaries.

$$\text{Green Patents}_{mt} = \sum_{s=1}^{S_{mt}} \text{Green Patents}_{smt} \quad (3)$$

where subscript s is the green-patenting subsidiary and S_{mt} is their total number in year t . Accordingly, $\text{Green Patents}_{smt}$ is the number of green patents of subsidiary s in year t .

Control variables include the following. First, Green Stringency Disparity captures the extent to which overall green stringency is greater in green-host countries (where the MNE generates green patents) than in the third country (where profits are observed). This variable controls for the potential mismatch in regulatory expectations that may undermine market demand. When third-country regulations are less stringent, local adopters may perceive green

technologies developed in stricter environments as unrealistic or less relevant (e.g., Jaffe et al., 2002; Mansfield, 1968), dampening demand and reducing revenue potential. MNEs may face lower price realization, weaker local demand, and increased adoption barriers due to limited infrastructure or user readiness. For each MNE m in year t , the average EPS score across green-host countries is:

$$\text{Green Host EPS}_{mt}^r = \frac{\sum_{s=1}^{S_{mt}} \text{Green Host EPS}_{smt}^r}{S_{mt}} \quad (4)$$

The corresponding average EPS score for the third country is:

$$\text{Third EPS}_{mit}^r = \frac{\sum_{j=1}^{J_{mit}} \text{Third EPS}_{jmit}^r}{J_{mit}} \quad (5)$$

where superscript r means EPS type: All, Market-Based, and Non-market, and sub-indicators (as shown in Table S2) within these broad categories, and J_{mit} is the total number of non-green-patenting-subsidiaries belonging to the MNE m in third country i in year t . The disparity is then computed as:

$$\text{Green Stringency Disparity}_{jmit}^r = \text{Green Host EPS}_{mt}^r - \text{Third EPS}_{mit}^r \quad (6)$$

Further controls include the following. *Greater Third-Country Green Tax and Green R&D Expenditure* is a dummy variable that takes the value 1 if the combined score of Third-Country Green Taxes (P21) and Green R&D expenditures (P32) is greater than that in the Green-host Country, and 0 otherwise. This variable captures the potential demand-augmenting effect of stronger third-country tax and R&D subsidy incentives (Popp, 2002). *Third-Country Asset* is the sum of fixed assets held by non-green-patenting subsidiaries of an MNE m in third country i , controlling for operational scale. The subsidiary-level operational data are obtained from Orbis. *MNE Diversification in Third Country* controls for operational breadth, measured as the number of distinct two-digit SIC industries in which MNE m operates in country i . *Historical Green Patenting in Third Country* controls for historical green innovation activity before 2014, measured by a 5-year moving count of total number of green patent classes associated with the MNE's third-country subsidiaries. *SDG Progress in Third Country* controls for the potential stimulus effect arising from the introduction of SDGs framework in a country, measured by SDG Progress Index (Sachs et al., 2024). *Year* dummies are introduced to control for broader time-related variations in firm performance.

Analyses

Stage 1: Local effects of green stringency

Table 1 reports descriptive statistics and the correlation matrix. We adopted a negative binomial model owing to some zero values in our dependent variable – subsidiary patent count (green patents may not be granted every year). Our subsidiary-level observations are panel data to account for variations in subsidiary behaviors both over time within subsidiary and between subsidiaries. We selected a Poisson model which caters for the number of occurrences of an event (green patent counts) (Coleman, 1964). We use the Stata command, `xtpoisson`, with random effects, because of the inclusion of time-invariant independent variables in our model. We calculate the variance inflation factor (VIF) for each variable to identify potential multicollinearity. The average and maximum VIF for each individual model are reported in Table 3. The VIF of each variable in our model is below the acceptable level of 10 (Neter, Wasserman, & Kutner, 1985), indicating no serious problems of multicollinearity.

Table 2 reports the regression results. Model (1) includes only control variables. In Model (2), the coefficient of *Green Stringency: Market-Based* is 2.546 and significant ($p = 0.009$), while the coefficient of *Green Stringency: Non-market* is insignificant ($p = 0.568$), thus supporting hypothesis H1. To interpret this effect in the original units of *Green Stringency: Market-Based* (before logarithmic transformation), we compute the marginal effect at its mean. The incidence rate ratio associated with increasing stringency in original value from 4.434 to 5.434 (i.e., a one-unit increase) is approximately 1.67, i.e., the expected count of green patents increases by about 101.67% when stringency values increase by one unit at its mean value. Figure 1 (left panel) visualizes this effect by plotting predicted green patents against host-country market-based stringency, holding other variables at their sample means and calibrating the level at the overall mean patent count; it therefore represents the marginal effect for a typical subsidiary-year around the mean stringency level. Key controls, *Subsidiary R&D Expenditure*, *Subsidiary Sales*, and *Host-Country Openness to Inward FDI* have positive and significant effects, suggesting the importance of demand-side factors in host countries.

Additional analyses

Model (3) introduces the variable *Green Stringency* (using the overall EPS index composed of both Market-Based EPS and Non-market EPS and lagged for 6 years). Its coefficient is insignificant, confirming our approach to separately

Table 1 Descriptive statistics and correlation matrix (stage 1)

Variable	N	Mean	S.D.	Min	Max	1	2	3	4	5
1 Green Patents Count of a Subsidiary	943	3.486	20.786	0	259	1				
2 Green Stringency: Market-Based, lagged by 6 years	943	4.434	1.885	0.250	9.250	0.11	1			
3 Green Stringency: Non-market, lagged by 6 years	943	12.300	1.266	5.000	14.000	0.13	0.26	1		
4 Green Stringency: Overall, lagged by 6 years	943	8.068	1.182	3.000	11.125	0.15	0.76	0.79	1	
5 Green Stringency: Market-Based, lagged by 7 years	856	4.522	1.893	0.250	9.250	0.11	0.93	0.23	0.71	1
6 Green Stringency: Non-market, lagged by 7 years	856	12.388	1.142	5.000	14.000	0.14	0.27	0.88	0.73	0.25
7 Green Stringency: Market-Based, lagged by 5 years	943	4.229	1.844	0.250	9.250	0.09	0.94	0.28	0.74	0.90
8 Green Stringency: Non-market, lagged by 5 years	943	12.042	1.575	5.000	14.000	0.14	0.33	0.79	0.70	0.26
9 SDG Progress in Host Country, lagged by 1 year	835	77.511	4.363	52.860	85.546	0.06	0.27	0.48	0.49	0.25
10 Host-Country Patent Stock	943	10.898	1.489	2.351	14.618	0.05	0.27	-0.05	0.03	0.27
11 Parent R&D Intensity	943	0.014	0.107	0	1.364	-0.07	-0.26	0.03	-0.12	-0.25
12 Parent Sales	943	3.5E+07	5.8E+07	-1E+06	4.67E+08	0.13	-0.11	0.01	-0.07	-0.11
13 Cultural Distance	943	0.861	3.083	-4.605	4.304	0.14	-0.10	0.06	-0.01	-0.07
14 Geographic Distance	943	7.923	1.361	5.849	10.433	-0.10	-0.04	-0.20	-0.16	-0.04
15 Institutional Distance	830	1.528	3.328	0.003	21.696	0.01	0.23	-0.13	0.09	0.24
16 Host-Country Openness to Inward FDI	943	5.731	9.995	-15.714	86.479	0.00	-0.41	-0.07	-0.29	-0.43
17 Host-Country Market Size	943	2.4E+12	2.9E+12	2E+11	1.78E+13	-0.01	0.19	-0.25	-0.13	0.19
18 Subsidiary Age	943	47.067	36.157	1	180	0.12	0.03	0.16	0.15	0.02
19 Subsidiary Sales	943	5.4E+09	1.2E+10	0	9.8E+10	0.33	-0.04	0.19	0.08	-0.03
20 Subsidiary R&D Intensity	943	0.176	0.973	0	7.250	-0.07	-0.15	-0.28	-0.28	-0.17
21 Subsidiary-Parent Technological Relatedness	943	0.469	0.499	0	1	0.17	-0.07	-0.14	-0.14	-0.08

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1																
0.30	1															
0.73	0.34	1														
0.44	0.29	0.50	1													
-0.09	0.28	-0.01	-0.07	1												
0.05	-0.27	0.02	-0.06	-0.06	1											
-0.04	-0.09	0.02	0.05	0.05	0.14	1										
0.10	-0.12	-0.03	-0.39	0.01	0.01	-0.07	1									
-0.20	-0.04	-0.17	-0.30	0.04	-0.04	-0.09	-0.10	1								
-0.12	0.23	-0.16	-0.12	-0.24	-0.24	-0.04	-0.29	-0.01	0.05	1						
0.00	-0.41	-0.04	-0.21	-0.26	-0.26	0.01	0.05	0.10	-0.03	-0.15	1					
-0.26	0.20	-0.19	-0.46	0.86	0.86	0.00	0.16	0.12	0.16	-0.19	-0.22	1				
0.15	0.03	0.15	0.16	-0.06	-0.06	0.19	0.04	-0.06	-0.25	0.00	-0.01	-0.16	1			
0.19	-0.04	0.16	-0.13	0.09	0.09	0.16	0.38	0.24	-0.18	-0.05	-0.04	0.15	0.22	1		
-0.32	-0.14	-0.23	-0.12	-0.12	0.33	0.02	0.13	-0.02	0.20	-0.08	-0.10	0.30	0.05	0.05	1	
-0.16	-0.06	-0.09	-0.04	-0.04	0.05	-0.12	0.05	-0.09	-0.01	0.05	0.05	0.08	-0.06	0.03	-0.06	1

Pearson correlations (two-tailed); Figures in bold are correlations significant at 5%. For ease of reading, mean, standard deviation, minimum, and maximum are statistics of variables in original form while correlations are calculated for variables in models, i.e., with logarithm (inverse hyperbolic sine) transformation (except dummies).



examine the effect of market-based stringency vis-à-vis non-market stringency.

There is no consensus on how long it takes to induce innovation outputs (Popp, 2019). We tested various lags for the stringency variables. The results of market-based and non-market green stringency variables lagged by 7 and 5 years, respectively, are reported in Models (5) and (6), reaffirming the stronger influence of market-based stringency on green patenting.

Institutional distance is theoretically endogenous with a range of other controls as MNEs typically geographically arbitrage institutional differences. We excluded this variable in our main estimations but included it in Model (4), demonstrating its expected direct effect remains insignificant.

IB research faces a challenge in directly measuring MNEs' contribution towards the SDGs "designed as country-level goals for governments to achieve, not as firm-level goals" (Montiel, Cuervo-Cazurra, Park, Antolín-López, & Husted, 2021: 1000). Thus, IB must rely on concepts such as externalities to explore beneficial social effects like sustainability. Logically, environmental targets and the SDGs are connected within the Green Agenda, with targets remaining a pillar of the 17 SDGs. Green innovation would be welcome evidence of MNEs addressing the SDGs, spurred by induced private returns that point to the resolution of an externality. We conducted additional analysis to explore if host countries' measured SDG progress over the previous year determines MNEs' green innovation. The results in Models (7)–(9) show that the effects of SDG Progress in Host Country are insignificant. We conclude that MNE green innovation responds more consistently to environmental regulatory stringency than to host-country SDG progress. This may reflect the indirect, characteristically country-level, nature of SDG metrics. The high VIF in Model (9) supports the exclusion of Host Country Patent Stock from Models (7) and (8) owing to multicollinearity concerns.

Stage 2: Cross-border effects of green stringency

Table 3 summarizes descriptive statistics and correlations for the second stage. All continuous variables are log-transformed before inclusion. We employ generalized least-squares regression with random effect (confirmed by a Hausman test). The average and maximum VIF for each individual model are reported in Table 4. The VIF of each variable in each model is below the maximum acceptable level of 10 (Neter et al., 1985), indicating no serious problems of multicollinearity.

Models (1)–(3) in Table 4 report our main results. We added the comparative stringency controls one at a time to gauge their contribution to the model. The full estimation is reported in Model (3) where the coefficient of Green Patents lagged by 4 years is 5.515 and significant ($p = 0.015$). This

result therefore supports Hypothesis H2. To interpret this effect in the original scale of the variables (before logarithmic transformations), we computed the marginal effect of Green Patents at its mean value (3.788). The result suggests that a one-unit increase in original green patent counts (to approximately 6.8 patents) is associated with an increase of approximately 207,337.400 USD in third-country net profits, holding all else constant. See Fig. 1 (right graph) for its visualization. The slope shows to an increase in predicted profits for an additional green patent at the mean, for a typical MNE-country-year in our sample, holding other covariates constant. Green Stringency Disparity has a negative and significant effect ($\beta = -1.840$, $p = 0.023$), while Greater Third-Country Green Tax and Green R&D Expenditure has a positive and significant effect ($\beta = 4.220$, $p = 0.035$), affirming the value of these contextual controls.

Additional analyses

We added profit margin to check robustness. The results, reported in Model (4), confirm the significance of cross-border effects; the coefficient for Green Patents lagged by 4 years is significant ($p = 0.003$). Different lags of the focal variable provide further robustness checks. We tested various lags for the green patents variable concerned. The Model (5) results support our estimation's robustness; the coefficient for Green Patents lagged by 7 years is significant ($p = 0.048$).

When distinguishing between market-based and non-market stringency, market-based green stringency disparity has a mix of positive and negative parity scores. This contrasts with the only positive scores (parity in one direction) of non-market green stringency disparity. We conducted additional analyses of the variable, Greater Third-Country Market-Based Stringency, taking a value of 1 if third-country stringency is greater than green-host stringency, and the results are reported in Model (6). Its coefficient is insignificant ($p = 0.512$), confirming that when market-based green stringency in third countries exceeds green-host countries this does not influence MNEs' third-country profits. MNE profits remain driven by MNEs' prior green patenting.

We controlled for Third Country Assets to capture the influence of an MNE's local operational scale on its profits. Since sales and asset are endogenous of each other and often highly correlated, for completeness we added a "return on sales" variable (Yang, Martins, & Driffield, 2013), Net Profit over Sales in Third Country. This variable's coefficient, reported in Model (7), is significant ($p = 0.001$), suggesting that MNEs' third-market profitability is shaped by a combination of earlier green innovation, local operational intensity, and market presence.



Table 2 Stage 1 estimation results (dependent variable: green patents count of a subsidiary)

Green Patents Count	Main results		Additional analyses						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables		Stringency variables lagged by 6 years	Composite stringency variable, lagged by 6 years	Effect of Institutional Distance	Stringency variables lagged by 7 years	Stringency variables lagged by 5 years	Effect of previous year's SDG progress		
H1: Green Stringency: Market-Based		2.546 (0.908) [0.009]		2.215 (0.752) [0.019]	2.334 (0.835) [0.018]	2.260 (0.807) [0.022]	2.306 (0.797) [0.016]		2.574 (0.854) [0.004]
H1: Green Stringency: Non-market		2.310 (3.386) [0.568]		1.602 (2.190) [0.730]	2.036 (3.249) [0.656]	6.110 (5.380) [0.040]	1.580 (3.057) [0.813]		1.052 (1.908) [0.978]
Green Stringency: Overall			7.535 (10.909) [0.163]					5.256 (6.864) [0.204]	
SDG Progress in Host Country							2696.133 (16939.750) [0.209]	6306.146 (41509.763) [0.184]	87.173 (531.766) [0.464]
Host-Country Patent Stock	1.376 (0.396) [0.267]	1.403 (0.377) [0.208]	1.343 (0.380) [0.297]	1.496 (0.349) [0.084]	1.445 (0.443) [0.230]	1.289 (0.354) [0.355]			1.331 (0.372) [0.307]
Parent R&D Intensity	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]	0.001 (0.001) [0.001]
Parent Sales	1.262 (0.200) [0.140]	1.229 (0.167) [0.130]	1.242 (0.178) [0.132]	1.181 (0.153) [0.197]	1.301 (0.200) [0.087]	1.202 (0.148) [0.136]	1.239 (0.163) [0.104]	1.248 (0.171) [0.105]	1.251 (0.170) [0.100]
Host-Country Openness to Inward FDI	1.088 (0.048) [0.060]	1.110 (0.051) [0.023]	1.101 (0.051) [0.038]	1.105 (0.047) [0.018]	1.074 (0.064) [0.230]	1.064 (0.036) [0.066]	1.098 (0.044) [0.020]	1.091 (0.044) [0.032]	1.096 (0.044) [0.022]
Subsidiary Sales	1.275 (0.122) [0.011]	1.259 (0.120) [0.015]	1.260 (0.123) [0.018]	1.253 (0.124) [0.023]	1.270 (0.128) [0.018]	1.254 (0.107) [0.008]	1.172 (0.097) [0.056]	1.169 (0.100) [0.069]	1.169 (0.097) [0.061]
Subsidiary R&D Intensity	0.444 (0.136) [0.008]	0.514 (0.135) [0.011]	0.483 (0.130) [0.007]	0.462 (0.154) [0.021]	0.656 (0.171) [0.106]	0.450 (0.122) [0.003]	0.537 (0.193) [0.084]	0.503 (0.182) [0.058]	0.518 (0.178) [0.055]
Subsidiary Age	1.400 (0.311) [0.129]	1.372 (0.293) [0.138]	1.395 (0.303) [0.126]	1.242 (0.265) [0.308]	1.276 (0.270) [0.249]	1.370 (0.278) [0.120]	1.222 (0.258) [0.343]	1.224 (0.258) [0.337]	1.176 (0.264) [0.470]
Subsidiary–Parent Technological Relatedness	1.460 (0.509) [0.278]	1.664 (0.562) [0.132]	1.571 (0.534) [0.184]	1.831 (0.638) [0.083]	2.022 (0.715) [0.047]	1.693 (0.560) [0.111]	1.872 (0.709) [0.098]	1.787 (0.676) [0.125]	1.926 (0.748) [0.091]



Table 2 (continued)

	Main results		Additional analyses						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Green Patents Count									
Variables		Stringency variables lagged by 6 years	Composite stringency variable, lagged by 6 years	Effect of Institutional Distance	Stringency variables lagged by 7 years	Stringency variables lagged by 5 years	Effect of previous year's SDG progress		
Host-Country Market Size	0.607 (0.247) [0.220]	0.555 (0.206) [0.113]	0.642 (0.257) [0.267]	0.511 (0.164) [0.037]	0.486 (0.203) [0.084]	0.641 (0.241) [0.238]	0.910 (0.190) [0.652]	1.011 (0.207) [0.959]	0.597 (0.262) [0.240]
Cultural Distance	1.072 (0.056) [0.179]	1.084 (0.054) [0.109]	1.066 (0.053) [0.202]	1.116 (0.064) [0.054]	1.070 (0.055) [0.187]	1.077 (0.051) [0.118]	1.182 (0.083) [0.018]	1.172 (0.081) [0.022]	1.178 (0.084) [0.022]
Geographic Distance	0.975 (0.130) [0.847]	1.008 (0.135) [0.955]	0.995 (0.132) [0.971]	1.020 (0.150) [0.894]	0.978 (0.136) [0.871]	0.994 (0.130) [0.963]	1.064 (0.173) [0.703]	1.068 (0.172) [0.682]	1.065 (0.173) [0.699]
Institutional Distance				1.407 (0.354) [0.175]					
Constant	0.275 (2.458) [0.885]	0.031 (0.312) [0.732]	0.001 (0.003) [0.423]	1.472 (13.238) [0.966]	0.781 (8.202) [0.981]	0.001 (0.001) [0.330]	0.001 (0.001) [0.139]	0.001 (0.001) [0.100]	0.001 (0.001) [0.506]
Industry effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
Observations	943	943	943	830	856	1040	835	835	835
Number of subsidiaries	103	103	103	103	87	113	102	102	102
VIF Average/Maximum	2.06/5.00	2.19/6.59	2.15/5.64	2.19/6.60	2.42/6.66	2.25/6.28	1.97/3.85	1.95/3.85	2.62/13.74
Wald Chi2	6.596e+06	5.427e+06	5.733e+06	5.097e+06	1485	2.626e+06	5.289e+06	5.709e+06	5.804e+06
Prob > Chi2	0	0	0	0	0	0	0	0	0

Reported are exponentiated coefficients, i.e., incidence-rate ratios. Robust standard errors are in parentheses. P values are in square brackets.

Discussion

This study revisits Ronald Coase's seminal theories of the firm (1937) and the problem of social cost (Coase, 1960) as a means of putting forward a Coasean institutional perspective on MNEs as agents of transnational green governance. We build on the theorization that firms internalize markets to overcome both external market inefficiencies and unpriced social and environmental externalities when international public transaction costs are high. On the strength of this, we offer a framework to theorize that MNEs can serve as coordination mechanisms for pro-environmental innovation across borders. We test two hypotheses to evaluate the dual

role of national green stringency – both as a local inducement and as a trigger for international value creation and capture.

Our results show that in the domestic economy, where we would expect local effects, there is a strong and positive influence on subsidiaries' green patenting activity stimulated by price as opposed to non-price signals. This supports Hypothesis 1. Our findings provide evidence that continuous, price-mediated signals create clearer and more sustained incentives for innovation than non-market measures. In particular, it is the policy mix that is important, rather than the level of overall stringency. From the point of view of firms, they would require clarity in the direction of



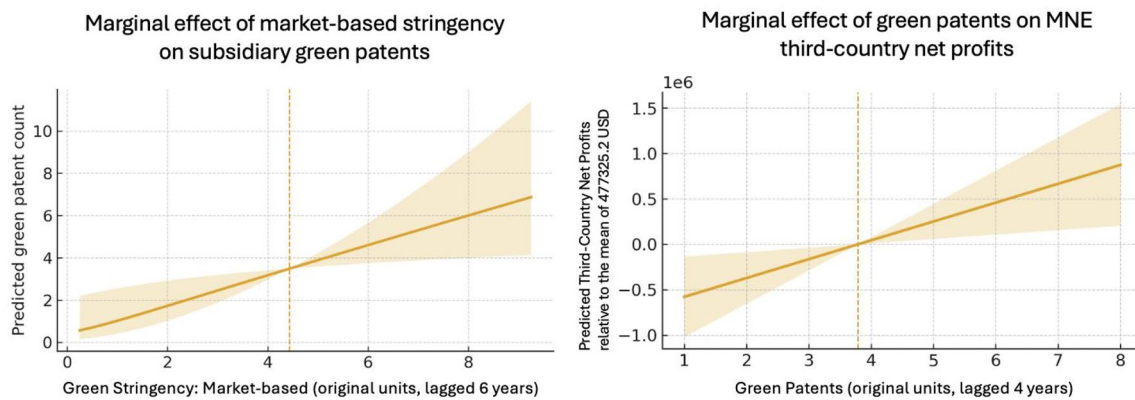


Fig. 1 Marginal effects of stage 1 and stage 2

environmental stringency to make green innovation investment decisions. With a policy mix that sends the right signals that innovation will be rewarded, subsidiaries respond to such incentives by developing new technologies and processes, effectively assimilating regulatory pressures using their capabilities and internal markets established by their parent MNEs. In Coasean (1937) terms, green market instruments create a bottom-up incentive for the firm to grow. However, this mechanism is initiated through the Pigouvian principle of harnessing price signals to create internal markets within firms for externalities, augmented by the domestic demand-pull effect of the Porter Hypothesis. By contrast, non-market instruments provide little motivation to the innovation that is at the heart of the IGI hypothesis.

Supporting Hypothesis 2, we find that green innovations induced by host-country regulatory stringency benefit parent MNEs in third-country markets as recorded in the profits of MNE subsidiaries. The theoretical cross-border transmission mechanism that we have proposed starts with the induced green innovation supported under Hypothesis 1. It then suggests that MNEs' internal networks convert domestic regulatory stimuli into increased profitability abroad. This is through the private agency of MNEs responding to the opportunity to profitably exploit their innovative green proprietary technology. Because the innovation concerned is green, we can infer that the effects will also be green in those subsidiaries abroad that subsequently work the technology. Hypothesis 2 thus highlights that whereas Pigouvian instruments are designed to operate within national jurisdictions, the MNE is capable of extending and amplifying these effects internationally through the internal diffusion, deployment, and value capture of proprietary green technologies.

These findings taken together, in Coasean terms, support the view that MNEs collectively act as private institutional complements to the state. This applies in the domestic economy and, by reducing the international transaction costs of

coordinating, transferring, and enforcing green technologies, MNEs expand the effective reach of national market-based environmental regulation. Through their internal organization and innovation networks, MNEs offer a private-sector mechanism that propagates the effects of Pigouvian environmental policy across borders.

The significance of our findings is apposite to the aspirations of Nordhaus (2015). Nordhaus proposed the climate club as a mechanism to overcome global free-riding, being a combination of voluntary cooperation and enforcement through trade penalties. While conceptually elegant, the climate club solution faces high negotiation and enforcement costs under the Westphalian system of sovereign equality (Keohane & Victor, 2016). Our findings suggest that MNEs can perform many of the international coordination and enforcement functions envisioned by the climate club proposal, but through market and organizational mechanisms rather than intergovernmental treaties. Although we do not test directly how MNEs effectively embed carbon pricing, private green procurement standards, and technology licensing, for example, into their global value chains, we are able to infer that this is likely. We base this on the support we obtain for our hypothesized effects of the deployment of MNEs' innovative green technology abroad. We can surmise that MNEs create excludable benefits and internal sanctions – akin to club membership and dues – through the creation of an international internal market within the firm, without the need for formal state-level international agreements. As an institutional form the MNE may then provide a more feasible and cost-effective mechanism for addressing global environmental externalities than hard-to-negotiate and even harder to conclude treaties.

Table 3 Descriptive statistics and correlation matrix (stage 2)

Variable		N	Mean	S.D.	Min	Max
1	Third-Country Net Profit	160	477325.200	1654528.000	−2068152.000	13300000.000
2	Third-Country Profit Margin	156	9.434	14.038	−37.155	97.140
3	Green Patents, lagged by 4 years	160	3.788	3.016	1	17
4	Green Patents, lagged by 7 years	160	2.406	5.400	0	46
5	Green Stringency Disparity	160	2.443	4.187	−2.625	19.125
6	Greater Third-Country Green Tax and Green R&D Expenditure	160	10.984	2.395	2.500	14.000
7	Third-Country Asset	160	11600000.000	33500000.000	979.986	238000000.000
8	Third-Country Green Stringency: Market-Based	160	4.367	1.926	0.250	7.750
9	Third-Country Green Stringency: Non-Market	160	10.984	2.395	2.5	14
10	SDG Progress in Third Country, lagged by 1 year	160	77.740	5.425	57.114	85.968
11	MNE Diversification in Third Country	160	1.856	1.682	1	11
12	Historical Green Patenting in Third Country	160	4.331	11.047	0	97
13	Greater Third-Country Market-Based Green Stringency	160	0.344	0.476	0	1
14	Net Profits over Sales in Third Country	160	−0.019	0.642	−6.584	0.953
15	Year	160	2013.481	4.992	2001	2019

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1														
0.72	1													
0.03	0.01	1												
−0.06	−0.06	0.07	1											
0.00	0.02	0.14	0.11	1										
0.10	0.01	− 0.17	− 0.15	− 0.46	1									
0.27	0.00	0.07	0.20	0.06	− 0.12	1								
− 0.08	−0.04	−0.02	− 0.07	− 0.52	0.68	− 0.12	1							
−0.02	0.02	0.11	0.06	− 0.45	0.21	0.09	0.44	1						
0.06	0.06	0.06	0.13	− 0.28	0.49	0.20	0.41	0.32	1					
− 0.05	0.10	−0.03	−0.03	0.05	− 0.19	0.14	−0.02	− 0.05	0.01	1				
0.09	0.02	0.06	− 0.01	−0.11	−0.13	0.36	−0.02	0.02	0.03	0.55	1			
0.04	0.00	− 0.12	−0.04	−0.49	0.18	0.04	0.50	0.61	0.30	− 0.08	0.05	1		
0.51	0.69	− 0.05	−0.05	−0.12	0.03	0.01	−0.02	0.13	0.00	− 0.18	−0.08	0.09	1	
−0.01	0.04	− 0.06	0.00	− 0.32	0.11	− 0.42	0.52	0.69	0.12	− 0.24	− 0.29	0.06	0.09	1

Pearson correlations (two-tailed); Figures in bold are correlations significant at 5%. For ease of reading, mean, standard deviation, minimum, and maximum are statistics of variables in original form while correlations are calculated for variables in models, i.e., with logarithm (inverse hyperbolic sine) transformation (except dummies).

Conclusions

There are two central messages from our study. The first concerns the effective stimulation of green innovation and how a judicious policy mix achieves this. The second concerns the international transmission of green technology and how to realize its profitable exploitation in countries where it finds a ready application. Our findings support the internal market of MNEs offering an effective and, arguably, the most effective means to achieve this. In reaching these overarching conclusions, we contribute to IB theory in three ways. First, we integrate Pigouvian, Coasean, and induced

innovation perspectives to explain how firms and states can jointly address environmental externalities at different levels. Pigouvian top-down regulation corrects market prices; Coasean bottom-up organization economizes on transaction costs; and MNEs, functioning as micro climate-club-type arrangements, integrate both functions within transnational corporate systems. Second, we extend internalization theory by incorporating environmental externalities into its core theorization, reframing MNEs as hybrid institutions that both respond to, and propagate the fruits of, beneficial regulatory actions across borders. Third, we extend Coase's (1960) work on social cost into the international dimension



Table 4 Stage 2 estimation results (dependent variable: third-country net profit)

	Main results			Additional analysis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Third-Country Net Profits							
Variables	Green Patents lagged by 4 years			Third-Country Profit Margin	Green Patents lagged by 7 years	Effect of Greater Third-Country Market-Based Green Stringency	Effect of Third-Country Sales
H2: Green Patents	4.662 (1.968) [0.023]	5.280 (2.264) [0.025]	5.515 (2.157) [0.015]	1.434 (0.447) [0.003]	1.573 (0.769) [0.048]	5.324 (2.329) [0.028]	4.217 (1.865) [0.029]
Green Stringency Disparity		− 2.017 (0.770) [0.012]	− 1.840 (0.778) [0.023]	− 0.591 (0.245) [0.020]	− 1.157 (0.717) [0.115]	− 1.928 (0.759) [0.015]	− 1.508 (0.673) [0.031]
Greater Third-Country Green Tax and Green R&D Expenditure			4.220 (1.935) [0.035]	0.918 (0.540) [0.097]	3.965 (1.910) [0.044]		2.065 (1.800) [0.258]
Third-Country Asset	1.222 (0.359) [0.002]	1.189 (0.329) [0.001]	1.160 (0.325) [0.001]	0.125 (0.100) [0.223]	1.127 (0.318) [0.001]	1.236 (0.319) [0.001]	1.036 (0.310) [0.002]
Third-Country Green Stringency: Market-Based		− 5.761 (2.316) [0.017]	− 6.604 (2.540) [0.013]	− 1.481 (0.890) [0.104]	− 5.115 (2.461) [0.044]	− 6.442 (2.452) [0.012]	− 4.656 (2.434) [0.063]
Third-Country Green Stringency: Non-Market	− 4.216 (4.873) [0.392]	− 6.704 (5.210) [0.206]	− 6.429 (5.342) [0.236]	− 2.384 (1.102) [0.037]	− 2.878 (4.856) [0.557]	− 6.341 (5.138) [0.225]	− 4.648 (5.249) [0.381]
SDG Progress in Third Country	12.581 (13.097) [0.343]	8.753 (13.162) [0.510]	6.879 (12.053) [0.571]	2.065 (2.903) [0.481]	5.283 (10.327) [0.612]	8.813 (12.995) [0.502]	5.102 (10.728) [0.637]
MNE Diversification in Third Country	− 1.732 (2.618) [0.512]	− 2.021 (2.530) [0.429]	− 1.785 (2.469) [0.474]	0.179 (0.776) [0.819]	− 1.255 (2.522) [0.622]	− 1.941 (2.462) [0.435]	− 0.866 (2.100) [0.682]
Historical Green Patenting in Third Country	1.274 (1.016) [0.217]	1.662 (1.054) [0.123]	1.938 (1.103) [0.087]	0.298 (0.317) [0.352]	1.562 (1.270) [0.226]	1.693 (1.073) [0.123]	1.514 (0.997) [0.137]
Greater Third-Country Market-Based Green Stringency						1.560 (2.354) [0.512]	
Net Profits over Sales in Third Country							8.949 (2.418) [0.001]
Constant	− 65.883 (58.130) [0.264]	− 22.056 (61.042) [0.720]	− 14.102 (55.837) [0.802]	− 1.071 (13.849) [0.939]	− 14.350 (49.370) [0.773]	− 23.571 (60.560) [0.699]	− 12.406 (47.861) [0.797]
Industry effects	Included	Included	Included	Included	Included	Included	Included
Year effects	Included	Included	Included	Included	Included	Included	Included



Table 4 (continued)

	Main results			Additional analysis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Green Patents lagged by 4 years			Third-Country Profit Margin	Green Patents lagged by 7 years	Effect of Greater Third-Country Market-Based Green Stringency	Effect of Third-Country Sales
Observations	160	160	160	158	160	160	160
R-squared	0.320	0.346	0.366	0.264	0.352	0.348	0.454
Number of Parent MNEs	40	40	40	41	40	40	40
VIF Average/Maximum	1.76/4.33	1.90/5.44	1.94/5.55	1.86/5.40	1.94/5.54	1.94/5.55	1.95/5.56

Robust standard errors are in parentheses. *P* values are in square brackets.

by showing how private corporate coordination can transform nationally-bounded regulatory incentives into effective international social value creation. In making the step from natural individuals to legal, or corporate ones, we draw on Coase's (1960) insight that the problem is of a reciprocal character; in our present case, this is also of an international nature. Without over-extending our argument we observe that, once created, green innovation sets up an interaction amenable to private resolution. The foreign subsidiary can profitably exploit the green innovation of its green sister in another jurisdiction and in so doing need not deny the originating subsidiary nor the parent MNE the opportunity to earn greater returns. When worked abroad, green technology designed to alleviate environmental social harm, fulfills the reciprocal bargain to bear part of the cost of the solution. The interesting question that arises is: how can the readiness of subsidiaries to exploit such innovation be raised to extend the environmental benefits still further? We do not investigate this issue here, but the question has merit. The social efficiency gains of MNEs extending the environmental benefits of innovation are readily apparent. However, barriers that militate against this may persist within jurisdictions.

For policymakers, our findings may help reconcile economic pragmatism with environmental urgency. The polarized ideological debate between regulation and voluntary corporate action is misplaced: regulation is not the problem; its design is. Our evidence suggests that a combination favoring market-based rather than non-market-based environmental instruments creates clearer and more continuous incentives for firms to innovate than the alternative of greater reliance on non-market designs centered on rigid compliance requirements (e.g., Czarnitzki & Lopes-Bento, 2020; Popp, 2002). The Green Agenda is wide, and the knowledge required to address it is highly technical. A Pigouvian top-down regulatory approach informed by the best available scientific evidence should, in principle, produce the optimal

mix of measures. In contrast, over reliance on Coasean bottom-up initiatives risks spawning "quick and dirty fixes" (e.g., Jaffe et al., 2002), potentially limiting the effectiveness of the Green Agenda, notwithstanding Coase's great principle of parsimony. Smart regulation lies in designing a coherent policy mix in which market-based instruments provide credible price signals while non-market instruments supply direction, standards, and safeguards. Such regulation creates the domestic inducement infrastructure for green innovation, leaving MNEs to diffuse resulting innovations internationally. Should more jurisdictions adopt smart designs then innovation inducement effects may become mutually reinforcing, creating a global ecosystem to intensify competitive pressures on firms to innovate, generating race-to-the-top dynamics.

Our findings suggest countries that lead in green regulation have the potential to benefit the world. We would expect that the induced innovation effects of a judicious market-based vs non-market policy on the environmental stringency scale up with market size. If so, then jurisdictions such as the European Union, the USA, and China could, if so motivated, act as systemic demand hubs for global sustainable innovation. Strong, credible, and sustained regulatory signals in these economies can generate global demand-pull effects (Popp, 2019), activating MNEs' globally distributed R&D networks and catalyzing invention, adoption, and diffusion far beyond national borders. It follows that leadership in green regulation does not require universal consensus; a few major markets acting decisively can produce a major shift in global innovation trajectories and price dynamics within green technology sectors.

For managers seeking to strengthen corporate environmental, social, and governance (ESG) performance, our findings highlight the strategic value of integrating environmental R&D, internal carbon pricing, and intellectual property management and exploitation across the firm's global



network. In principle, MNEs can make their own within-firm choices at lower transaction cost of international negotiation, leading to a superior international allocation of resources in terms of efficiency. This may outperform private climate clubs. If, as we suggest, kick started by smart regulation, it may bring resolution of the problem of international environmental external social cost closer within grasp.

We hope our analysis stimulates further research into private sector solutions to global sustainability challenges. Due to data constraints, we could not capture precise subsidiary and parent-level R&D investments. The limitations of current sustainability reporting (see van der Waal et al., 2021), being often symbolic rather than substantive, hinders the precise quantification of MNEs' green innovation efforts. Future research would benefit from greater transparency and standardized disclosure of MNEs' green R&D expenditures by location and project type. Another area of data constraint is the measurement of green stringency. Available indices capture regulatory stringency for only 40, mostly OECD, countries with considerable missing observations. This hampers any greater systematic investigation of the global green regulatory landscape. Future research could develop new or expanded green stringency indices, to include a wider set of economies and emerging regulatory domains such as biodiversity, circularity, and sustainable finance. A richer representation of global policy heterogeneity would allow more precise testing of how environmental governance interacts with MNEs' internalization strategies that yield international ripple effects of innovation. A further avenue is to explore how green innovations in one subsidiary trigger follow-on investments at a distance, i.e., technological adaptation or capability building elsewhere in the MNE network and its global value chain. Literature on globally distributed MNE R&D activities (Papanastassiou et al., 2020) and lead firms' value chain strategy (Buckley & Liesch, 2023) already points to such dynamics. A fruitful extension would be to examine how diverse innovation implementation processes (e.g., Qin, Muskat, Ambrosini, Mair, & Chih, 2026) are activated through smart regulatory design. Last but not least, research is needed for effective measurement and monitoring of outcomes of green policy mix so that reductions in social cost and the creation of social value remain distributionally equitable, especially for under-resourced economies most exposed to global climate risks.

The Green Agenda is more than worthy of smart regulation. Our findings suggest that Pigouvian-style regulation remains indispensable for initiating environmental policy stringency. It overcomes a core limitation of extending Coasean principles of private resolution that become strained when affected parties are diffuse, geographically distant, and difficult to identify. When externalities occur at a global scale, it is almost insurmountable to allocate accountability with sufficient precision through decentralized bargaining

alone. Any external social cost, or harm, in remote jurisdictions should trouble us all. Our analysis suggests that international business may offer an effective pathway to alleviating these global harms.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1057/s41267-026-00872-9>.

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Data availability The data underlying this study are not publicly available because access is restricted by third-party property rights associated with the Orbis Databases. To support research transparency, we provide a Standardised Research Protocol for Identifying Green Patents in the Orbis Intellectual Property Database, which sets out the methodological principles used to identify green patents for a given set of firms. This protocol is available as online supplementary material and has been deposited in Zenodo under <https://doi.org/10.5281/zenodo.19581607>.

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