Using Standards to Promote Sustainable Development

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Abstract

Standards are among the most popular and effective tools for protecting the environment. By imposing technological constraints on production processes, products, or limits on polluting emissions and toxins, they help mitigate the harmful impact of economic activities on human health, biodiversity, and climate. This paper investigates to what extent standards can foster sustainable development. It explores the role of standards within the pool of environmental policy instruments, addressing when they should be part of the optimal policy mix and what complementary policies should support them. It also discusses whether standards should be mandatory or voluntary, and how they interact with international trade. The paper is illustrated with examples from developing countries.

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Introduction

Governments have a crucial responsibility to protect citizens from the detrimental effects of economic activities. Among the various policy tools available, standards are one of the most reliable and effective instruments for addressing market failures, such as asymmetric information about product quality, underinvestment in safety as a public good, and environmental externalities. This paper focuses on the role of standards as a policy instrument for sustainable development that preserves biodiversity and human health.

The paper is structured as follows. First, it outlines the policy instruments that address environmental issues. Second, it discusses the contexts in which environmental standards should be integrated into the policy framework. Third, it explores which policies should complement standards to enhance their effectiveness on protecting our environment. Fourth, it compares the performance of voluntary and mandatory standards. It then examines the relationship between standards and international trade before concluding by summarizing key messages.

Environmental policy instruments

Two types of policy tools are usually considered: command-and-control instruments and market-based instruments (Antweiler 2014; Coria and Sterner 2012; Goulder and Parry 2008). A third category, information and nudges, is increasingly recognized as a complementary approach to shaping environmental behavior (Carlsson et al. 2021; OECD 2017).

Command-and-control instruments. *Command-and-control* instruments are regulatory tools that impose restrictions on the technological choices made by firms or consumers. Public authorities "command" these restrictions during the design phase and then "control" compliance through enforcement. Technological standards mandate specific technologies (such as requiring a scrubber on a power plant) or inputs (such as banning harmful pesticides). Emission standards set upper limits on pollutants used as inputs (such as restricting toxic chemicals) or released as byproducts of the production process (such as nitrogen oxides [NOx], carbon dioxide [CO_2], particulates, or wastewater).

Standards can be applied at different levels—on manufacturing plants, on products (such as NOx emission limits for vehicles), or at local monitoring stations (such as biological oxygen demand [BOD] in a watershed). Firms may have more flexibility in how they meet emission standards than technological standards. For instance, a power plant aiming to comply with air quality standards might adopt alternatives to scrubbers, such as improving its combustion process, using lower-sulfur coal, or switching to natural gas. Compliance strategies for emission standards can vary depending on firms' best available technologies. Ambient pollution standards for air or water may lead to different emission reductions across firms, depending on local pollution sources (for example, from cars or trucks) or environmental conditions (for example, wind speed, which affects the dispersion of pollutants).

Command-and-control instruments are fundamentally "*engineering-based*" in nature because they directly address the production processes and product designs of companies.

Market-based instruments. *Market-based* instruments rely on market mechanisms to tackle environmental issues.[1] Rooted in economic theory, these instruments are based on the view that pollution as an externality that markets fail to manage efficiently. These market failures can be effectively mitigated by either pricing polluting emissions, or by assigning pollution rights with tradable allowances for pollution.

With the first (price-based) approach, emissions are taxed, or emission reductions are incentivized through subsidies. Under the second (quantity-based) approach, polluters are allocated emission allowances that they can trade among themselves. The regulator sets a total cap on emissions (often through allowances or permits) or establishes individual emission caps for each polluter. In the first scenario, pollution allowances are either auctioned or allocated freely, typically based on historical emissions, or a combination of both. In the second scenario, known as cap-and-trade, polluters can sell allowances if their emissions are below the emission cap, or buy additional allowances if they exceed their limits. In both systems, emissions are typically expressed either in absolute terms (such as tons of CO_2-equivalent emissions)[2] or relative to output (such as tons of CO_2 per megawatt-hour of electricity produced). Market-based instruments are *"economic"* in nature because they utilize economic principles to address the inefficiencies created by pollution. These tools are generally regarded as more efficient than command-and-control regulations because they provide ongoing incentives for innovation and cost-effective pollution reduction. However, they also have challenges, such as uncertainty in achieving specific pollution reduction targets and the potential creation of pollution "hotspots" if not properly designed.

It is worth mentioning that the distinction between command-and-control and market-based instruments is not always clear-cut. *Tradable emission standards*, or *tradable performance standards* (Fischer 2019), blend elements of both. These standards impose limits on energy use, input, or emission intensity per output (such as fuel consumption or CO_2 emissions per 100 kilometers for cars, or per megawatt-hour for power plants), thus restricting technological choices. However, firms can exceed these limits at a cost by purchasing credits to offset their excess emissions. Firms with emission intensity below the standard earn credits for each unit of emission saved, which they can sell to firms that exceed the standard. For instance, in the United States, the Corporate Average Fuel Economy (CAFE) standards set energy efficiency targets for car manufacturers' fleets (measured in miles per gallon). Thirty US states and Washington, DC have enacted Renewable Portfolio Standards (RPSs) mandating electricity retailers to procure or generate a minimum share of their power from renewable sources (Deschenes, Malloy, and McDonald 2023). These standards are often paired with credit systems (or certificates) that can be traded in markets. The RPSs are implemented with Renewable Energy Credits (RECs), which are used to ensure compliance with the policy. Renewable energy producers receive a REC for each megawatt-hour produced and injected into the grid. Utilities must show ownership of a required number of RECs to comply with the RPS policy. Utilities can either use RECs they generate or RECs they purchase from power generators to show compliance.

Information-based instruments. *Information and nudges* represent a third type of policy instrument designed to encourage firms and consumers to reduce their environmental impact (Carlsson et al. 2021; OECD 2017).[3] Examples include social comparisons of energy and water consumption on utility bills, eco-friendly product labeling (such as carbon footprint or energy efficiency), and reporting of the environmental performance of firms (such as mandatory emission reporting or socially responsible certifications).

Unlike market-based instruments, nudges do not rely on financial incentives, and unlike command-and-control regulations, they do not mandate specific behaviors or technological choices. Polluters are not subject to legal penalties or fines for failing to reduce their environmental impact; instead, they are free to pollute as much as they want. Green labels and the certification of firms' environmental performance (such as ISO 14000)[4] are "voluntary standards" because unlabeled products and uncertified firms are not forbidden. The guidelines and the procedures for being granted the label or certification are standardized. Labels on the energy efficiency of products (such as cars, refrigerators, and air conditioners) or housing are also standardized in their classification, in addition to being mandatory. However, the labeling system does not impose any obligation to meet a minimal level of energy efficiency by itself (though it is often associated with a mandatory lower bound on energy efficiency).

Other information measures are both mandatory and standardized. For instance, in the United States, highly polluting firms are required to report emissions from several pollutants to the federal Environmental Protection Agency (EPA) through the Toxic Release Inventory (TRI). It has been associated with a "voluntary" program to reduce the emissions of 17 targeted chemicals by 33 percent or 50 percent through the so-called 30/50 Program (Khanna and Damon 1999). In the European Union, the Corporate Sustainability Reporting Directive (CSRD) requires large companies to publish regular reports "on the social and environmental risks they face, and on how their activities impact people and the environment."

Information and nudges are considered "*cognitive*" instruments because they appeal to individuals' ethical reasoning and emotions, such as feelings of guilt or psychological rewards, to influence behavior—whether as consumers, investors, or managers.

Table 1 provides examples of the three types of instruments for several pollutants and natural resources.

Table 1. Examples of policy instruments of the three types for various pollutants

Pollutants and natural resources	Command-and-control instruments	Market-based instruments	Information and nudges
Air quality: particulate matters, SO_2, and NOx	Scrubbers; fuel quality standards; catalytic converters; restrictions on new power plants or manufacturing plants; cap on emissions at the plant level; ban of coal power plants.	Taxes on emissions; SO_2 cap-and-trade system in the United States; subsidies for cleaner technologies; feebates; traffic congestion fees.	Reporting of manufacturing plant's environmental performance; ISO 14001 certification; EPA's 30/50 program.
Greenhouse gas: CO_2	Ban of coal power plants, energy-intensity standards.	Tax on carbon emissions; EU's emission trading scheme; feed-in tariffs; renewable portfolio standards.	Carbon footprint disclosure and labels; green electricity contracts.
Water (quality)	Ban on pesticides and on hazardous chemicals; water quality standards; limitations on pesticide and chemical use; safety measures.	Effluent charges; water quality trading programs.	Public disclosure of water quality at the municipal level; organic food labeling.
Solid waste	Technological standards on recycling, mandatory recycling.	Payment of based on waste weight, deposit-refund schemes.	Information on recycling-based inputs on products.
Water (quantity)	Non-tradable quotas; irrigation water turns; limitations on pump power and wells.	Water pricing and taxes; water markets.	Information on water scarcity; comparison of household's water consumption in the water bill.
Fisheries	Net size; fishing days; territorial use rights.	Tradable fishing quotas; fishing licenses; fishing vessel buyback.	Marine Stewardship Council (MSC) label.
Forests	Forest code; provision of parks; zoning.	Property rights; tariffs on imported forest products.	Forest Stewardship Council (FSC) label.

Source: Original compilations for this volume.
Note: CO_2 = carbon dioxide; EPA = United States Environmental Protection Agency; EU = European Union; NOx = nitrogen oxides; SO_2 = sulfur dioxide.

When are standards part of an optimal policy mix?

The choice of policy instruments is largely context specific. It depends on various factors, such as the type of pollutant, available technologies, economic environment, and the institutional background. This section lists some features that make standards a part of the optimal policy mix.

Efficiency: incentivizing pollution reduction with more flexibility at a lower cost. It is generally accepted that market-based instruments are more efficient in preserving the environment and natural resources for at least two reasons. The first reason has to do with individual incentives to reduce pollution. With environmental standards, firms have no incentive to invest in pollution abatement technologies that are not mandated by the standard, even if these technologies are cheaper. They also have no incentive to reduce pollution beyond the levels mandated by the standard. In contrast, when emissions are priced with a tax or with costly emission allowances, firms are free to use the best available technology to control their emissions. Furthermore, they have an incentive to reduce pollution further as long as it is cheaper than paying the emission tax or buying emission allowances. The second reason why market-based instruments dominate is related to the variation of abatement costs within an industry. Pricing emissions is cost-effective in the sense that it minimizes the cost of reducing pollution to a given level. Firms react to a price on emissions by equalizing their marginal cost of abatement to the emission price. In contrast, with an emission standard uniformly applied to all firms, some firms might reduce emissions at a higher marginal cost than others.

Green consumerism. In a recent study, Ambec and De Donder (2024) challenge the dominance of market-based environmental policy over environmental standards in the presence of *green consumerism*. Assuming that some consumers are willing to pay more for greener products, they show that emission taxes turn out to be less cost-effective than an emission standard. Firms producing greener goods invest more in pollution abatement to differentiate their product from the brown version produced by their competitors. The presence of green consumers induces a gap between the marginal abatement costs of firms producing the green version and the brown version of the good. The tax leads to a higher gap between the marginal abatement costs than the standard to achieve the same level of pollution reduction. As a result, taxing emissions is less cost-effective than setting an environmental standard.

Addressing local versus global pollutants. Standards are particularly well-suited for addressing *local pollutants* rather than global ones. They play a critical role in controlling substances such as nitrogen oxides, sulfur oxides, and particulate matter that degrade air quality, as well as pesticides, phosphorus, nitrogen, and ash that contaminate surface and groundwater. The impact of these pollutants on health and biodiversity depends on their local concentration. The objective of environmental regulation is to ensure that pollution levels do not exceed thresholds beyond which the harm becomes too costly for society to bear. Public authorities establish limits on pollutant concentrations in air and water through laws, often based on guidelines from the World Health Organization (WHO). These limits are both expressed in short-term impacts (for example, during peak days) and long-term impacts (for example, annually).

Market-based instruments do not guarantee that pollution concentrations will remain below a specific cap locally. With an emission tax, the resulting pollution levels depend on how polluters respond to the tax. The extent to which they reduce their emissions varies according to their own abatement costs, which are related to their technology. Consequently, the regulator has limited control over the effect of the tax on ambient pollution. This means that pollution concentration could end up being higher or lower than expected. With a cap-and-trade system, the regulator loses control over the geographical distribution of pollution: after trading, allowance buyers may be clustered in specific areas, potentially creating localized "hotspots" of pollution. This concern arose particularly with the US SO_2 cap-and-trade system implemented under the Clean Air Act of 1990. Despite the overall

reduction of SO_2 emissions in the United States, trading led to increased SO_2 emissions in the Ohio Valley, Burtraw and Mansur (1999) found.

Dealing with very high marginal damages. The superiority of standards in addressing local ambient pollution can be rationalized by following Martin Weitzman's seminal comparison of price versus quantity regulations (Weitzman 1974). The paper compares the performance of both types of regulation in a framework where abatement costs are known only to the firm as a firm's private information. The analysis captures the already mentioned trade-off: minimizing abatement costs with a price regulation versus controlling the pollution level with a quantity regulation. Weitzman's main result is that quantity regulations such as emission standards dominate when the slope of the marginal environmental damage is higher than the slope of the marginal abatement cost measured at the firm or industry level. If the marginal damage curve for environmental pollution is steeply sloped, damages for additional emission units above some threshold are very high. This feature is consistent with the idea that the impacts on human health and/or biodiversity are excessive above some level of pollution concentration, as is commonly acknowledged for local air and water pollutants.

Measurement issues. The type of environmental standard that is implemented depends on how and where the pollution level is *measured*. Emission standards apply to pollution measured at the source, while ambient pollution standards are defined at pollution monitoring stations. Both types of standards are complementary because they address different issues: forcing polluters to curb emissions and limiting exposure to pollution. In other words, emission standards directly limit pollutants at their origin, while ambient standards ensure that overall exposure remains within safe limits.

For instance, thermal power and manufacturing facilities must comply with upper limits on NOx, sulfur dioxide (SO_2), and particulate matter, sometimes combined with technology standards that impose the installation of scrubbers or the use of cleaner fuels. To make sure that ambient air pollution is also under control, local authorities, in parallel, restrict industrial polluting activities temporarily during periods of peak pollution due to weather conditions, such as a lack of wind to disperse pollution, temperature inversions that trap pollutants, or hot days that favor the concentration of ozone (Auffhammer, Bento, and Lowe 2009; Zou 2021).

In the transportation sector, the deterioration of air quality is mitigated by standards on NOx and particulate matter emitted by cars and trucks, which are required to install pollution abatement devices such as catalytic converters. However, because the source of pollution is mobile, high traffic causes pollution peaks in cities during rush hours. Complementary regulations such as the ban on older diesel cars in city centers, the so-called "low emission zones" that exclude the most polluting cars during peak pollution events, or driving restrictions based on the last digit of the vehicle's license plate (Barahona, Gallego, and Montero 2020; Li 2018) target ambient pollution concentration.

Water pollution is managed by setting limits on pollutants discharged by industrial plants and agricultural operations. For instance, pulp and paper mills must comply with limitations on organic pollution measured as biological oxygen demand (BOD) and total suspended solids. The spread of pesticides and fertilizers is regulated with specific guidelines including maximum application rates per hectare, buffer zones around water sources, and timing restrictions to minimize runoff. More stringent standards can be implemented if ambient water pollution exceeds the upper bound set by the regulation at upstream monitoring stations.

Box 1 illustrates how advanced technologies such as satellite data can help solve measurement issues to better enforce the forest code in the Amazon.

Box 1. Using satellite data to enforce the Forest Code in the Amazon

The Amazon rainforest provides many environmental services. It hosts one of the richest ecosystems in the world, regulates the local climate, and stores substantial carbon stocks. To protect the Amazon, Brazil adopted a very tight Forest Code. Deforestation is prohibited in indigenous territories and public forests, which account for approximately 50 percent and 13 percent of the Brazilian Amazon, respectively. In the remaining areas, farmers are required to preserve 80 percent of their land as forest. Nevertheless, about 3.4 million km² of the Brazilian Amazon Rainforest was lost between 1985 and 2020, mostly due to illegal conversion of forestland into pastureland. Clearly, enforcing the Forest Code remains a challenge in such a vast region.

The federal agency responsible for enforcing the Forest Code, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), is using satellite imagery to detect deforestation. Ferreira (2024) investigates how technological progress in satellite monitoring has improved enforcement. The study relies on a structural approach to model the full enforcement process, from the initial detection of infractions with deforestation alerts, to the selection of alerts for inspection, and ultimately, to the enforcement actions such as issuing fines to illegal loggers. The study finds that technical progress in satellite imageries has made deforestation in the Amazon three times more likely to be observed in real time today than it was ten years ago. The study finds there is 13 percent probability of fines in areas covered by deforestation alerts. Ferreira also quantifies the deterrence effect of the Forest Code enforcement process: a one percentage point increase in the probability of inspection reduces deforestation by 150 km², which amounts to about 2 percent of average annual deforestation.

Institutional capability. The *institutional context* should matter for the choice of policy instruments. Standards are easier to implement, monitor, and enforce than market-based instruments. As mentioned, technical standards are directed to technicians and engineers in charge of products and production processes. The technological constraints can easily be translated into investment, strategic choices, and procedures at the firm level. Emission standards are expressed in volumes or concentrations that can be easily measured and monitored for products (for example, on cars with smog inspections for NOx and particulates), farms, or manufacturing plants. In contrast, taxing and subsidizing emissions require administrating fiscal transfers (such as tax collection and revenue redistribution), which can be challenging in developing countries with a large informal sector. Cap-and-trade systems add further complexity because pollution rights must be legally defined, and trading necessitates a market infrastructure. Minimal institutional capacities are needed to implement and enforce market-based instruments, particularly for emission trading schemes (Stranlund 2017). Furthermore, as suggested by the case study reported in box 2, the ways standard are monitored and enforced matter to make them effective.

Box 2. A case study of emission standard monitoring and enforcement in India

Recent economic studies using randomized control trials (RCT) in India illustrate the challenges of enforcing emission standards in developing countries. Duflo et al. (2013) conducted an RCT on procedures to audit water and air pollution emitted by textile manufacturing plants in the state of Gujarat. The procedure in place was fairly common: a plant hires and pays auditors to measure and report polluting emissions. The study was motivated by a suspicion of misreporting suggested by (1) anecdotal evidence that "the reported market price for an audit was often lower than the cost of collecting readings, suggesting that at least some readings were not even taken"; and (2) an unusually high proportion of reports showing emissions just below the standard, because they "are presumably less likely to attract regulatory attention than would be reports showing compliance by

a wide margin." In the study, some plants were randomly assigned to an alternative auditing procedure in which the auditing company was selected and paid by the researchers instead of the plant. Furthermore, a random sample of the auditor's readings was verified by an independent technical company.

The study found that emission readings reported with the new auditing procedure were more accurate. First, the reported emissions were more widely spread around the standard rather than just below. Second, they were more consistent with the readings performed by the independent company. The study also found that the plants subject to the new auditing procedure reduced their pollution emissions, suggesting that the auditing reform can not only improve reporting but can also enhance regulatory effectiveness.

In a follow-up study (Duflo et al. 2018), the same team of researchers modified the procedure for selecting the manufacturing plants that were to be audited. They were selected randomly instead of being left to the discretion of the regulators. Furthermore, the "treated" plants in the random auditing selection were audited more frequently. The random selection procedure increased compliance but only slightly. However, even if the procedure detected lack of compliance more frequently, plants were penalized less often. In contrast, the regulator's discretionary inspections tended to target the dirtiest plants—the extreme violators that were subject to the largest penalties.

In a recent study in the same area, Greenstone et al. (forthcoming) implemented a cap-and-trade system for randomly selected textile manufacturing plants instead of emission standards. They found that the emissions market increased compliance, reduced particulate emissions, and lowered abatement costs compared to non-tradable standards.

Safety. *Safety standards* are important precautionary measures to prevent environmental accidents, such as oil spills, methane leaks in natural gas fields, wastewater discharge during floods, toxic contamination of food, or radioactive leaks from nuclear power plants or waste. While alternative policies, such as holding potential polluters liable for accidents, may seem appealing, they can be ineffective in encouraging investments to enhance safety—especially in developing countries. Several factors favor underinvestment in safety, including delays and inefficiencies in the judicial system, corruption when high fines are imposed, and strategic default by the companies involved. As Shavell (1984) points out, safety standards must be implemented alongside liability regulations, particularly in countries with weak institutions, despite their potential inefficiency.

The policy mix with standards: Which instruments should complement standards?

Combining policies. In practice, addressing environmental issues typically involves a combination of policy instruments. Technological standards are often paired with subsidies that support investments needed for compliance. Fines are imposed when polluters exceed emission limits, usually in proportion to the extent of the violation, similar to an emission tax. For example, carbon dioxide emissions from energy consumption are regulated through a diverse set of policy tools, including basic energy efficiency standards for residential heating and cooling, energy performance labeling for appliances (a form of behavioral nudge), carbon taxes on fuel, emission trading schemes for thermal power plants, and subsidized feed-in tariffs and renewable portfolio standards for solar and wind energy, as well as mandatory reporting of corporate carbon footprints.

Enacting public policies at multiple levels: Local and global regulation. Certain local pollutants, such as NOx and SO_2, can travel long distances, crossing municipal, county, and even national borders. Similarly, wastewater flows from upstream to downstream areas within watersheds, often spanning jurisdictional boundaries. Natural resources such as fisheries, oil fields, and water are shared by multiple users—local communities, administrative entities, and firms—which creates a classic "common-pool resource" problem, leading to overexploitation and resource depletion. Managing pollution and natural resources that have *both local and global impacts* requires public policies at multiple levels. As mentioned, emission standards are effective for addressing localized pollution but should be complemented by market-based instruments such as emission taxes or cap-and-trade systems to manage transboundary pollution. The literature on "environmental federalism" highlights that decentralizing environmental regulation at the local level results in excessive pollution or resource extraction because local authorities often fail to internalize the externalities that spill over into other jurisdictions. This decentralization can lead to a "race to the bottom" in environmental standards. To address these challenges, supplementary policies should be implemented at higher levels—such as the watershed, national, federal, or international levels—to internalize these transboundary externalities. Local standards and market-based instruments such as taxes or cap-and-trade systems need to be coordinated effectively (Banzhaf and Chupp 2012; Williams III 2012).

Improving standards with emission pricing. Along this line, Ambec and Coria (2021) argue that emission standards can be better designed when polluting firms are incentivized to reduce emissions through market-based instruments such as an emission tax. The standard's stringency solves a trade-off between lowering environmental damage and increasing pollution abatement costs. The solution to this trade-off is difficult to assess when abatement costs are known only to firms as private information like in Weitzman (1974). However, when emissions are taxed, the reductions in firms' emissions that result from the tax provide useful information about the firms' abatement costs, which can be useful for setting the emission standard. Ambec and Coria (2021) explore how regulators can leverage this information to adjust the standard. Their theoretical analysis suggests that if firms reduce emissions more than required by the standard, the regulator updates the standard to become more stringent. They illustrate this with the case of NOx regulation in Sweden, where a national tax was combined with emission caps negotiated at the county level. In line with their theoretical predictions, they find that the firms that pay the NOx tax experience more frequent standard updates and more stringent revisions than those that are exempt. Their finding is also consistent with the regulatory update found by Greenstone et al. (forthcoming) following the introduction of a cap-and-state system (discussed in box 2). The regulator tightened the cap on emissions after observing the relatively low cost of compliance with the market-based instrument.

Should standards be mandatory or voluntary?

Not all environmental standards are mandatory; some are voluntary. Firms are free to adopt or not adopt standards that are promoted by governments or independent certification agencies.

Firms can choose to have their production processes and management practices evaluated by a certification body to earn the ISO 14001 certification for environmental management. The benefits of achieving ISO 14001 certification often outweigh the costs, as discussed in Ambec and Lanoie (2008).

Motivation for adopting voluntary standards. First, certification can open doors to specific markets, such as government procurement contracts, which often prioritize or restrict access to environmentally certified suppliers. Second, ISO 14001-certified firms are better positioned to supply other certified companies because selecting suppliers based on their environmental performance is often a requirement for maintaining certification. Third, ISO 14001 certification can improve relationships with external stakeholders such as governments, environmental groups, media, and local

communities. Fourth, certified companies may attract investment from socially responsible investors, reducing the cost of financial capital. Finally, certification can lower labor costs by attracting educated workers, including scientists, managers, and engineers, who may be willing to accept lower salaries in exchange for working at a reputable, environmentally responsible company.

Firms can also choose to certify their products with eco-labels, such as organic food certifications, green electricity with Renewable Energy Credits, Marine Stewardship Council (MSC) certification for fish and seafood, or Forest Stewardship Council (FSC) certification for wood products such as furniture. Eco-labeling serves as a product differentiation strategy that allows companies to target niche markets of environmentally conscious consumers. Even though green products are more expensive to produce, the supplementary cost can be more than offset by the ability to exert market power within these segments.

Making the standard voluntary instead of mandatory can be a relatively inexpensive way to overcome opposition from stakeholders, including powerful lobbies. To be effective, the standard should require a substantial improvement of environmental performance. It should also be widely adopted and enforced by credible certification agencies. However, voluntary standards have limitations.

Greenwashing. First, voluntary initiatives may lack the ambition and credibility needed to deliver effective environmental protection. Many companies engage in "greenwashing" by adopting weak or superficial environmental standards that fail to drive meaningful improvements. Numerous studies have found that voluntary standards often have little to no impact on environmental performance. For example, Vidovic and Khanna (2007) show that the decline in chemical releases reported to the Toxic Release Inventory in the United States cannot be attributed to the EPA's 33/50 Program. Similarly, Barla (2007) observes that while ISO 14001 adoption in Quebec's pulp and paper industry led to a 9 percent reduction in discharges affecting biological oxygen demand, it had no impact on total suspended solids or the quantity of rejected process water. Likewise, empirical studies have found limited (Blackman, Goff, and Planter 2018) or no (Rico-Sraffon et al. 2023) effect of FSC certification on deforestation. In a literature review of voluntary programs in developing countries (including the one reported in box 3), Blackman (2010) concludes that their impact on environmental performance is mixed.

Box 3. A voluntary program for environmental audit in Mexico

As part of a comprehensive examination of voluntary programs in developing countries, Blackman et al. (2010) examine the effectiveness of Mexico's Clean Industry Program (Programa Industria Limpia). The program was launched in 1992 to improve compliance with environmental standards in industrial sectors. Under the program, plants that voluntarily join agree to pay for an environmental audit conducted by an accredited auditor to assess their compliance with environmental regulations. If deficiencies are found, the plant negotiates an action plan with the regulatory authority to address the issues. In return, the plant is exempt from penalties, provided that it fulfills the commitments outlined in the action plan. Additionally, the plant receives a Clean Industry Certificate valid for two years, which exempts it from further audits during that period. The authors address two key questions: (1) Which firms are joining the program? and (2) Is the program effective in improving compliance with environmental standards?

Regarding the first question, the study reveals an unexpected result. Unlike other studies suggesting that voluntary programs typically attract firms that are already compliant with environmental standards, the dirtiest plants in Mexico were the ones most likely to join the Clean Industry Program. Specifically, plants that had recently been fined for noncompliance were more likely to participate, indicating that regulatory fines and future amnesty serve as motivating factors for program enrollment.

Regarding the second question, the authors find that participation in the program does not significantly reduce the likelihood that firms will be fined. However, this does not necessarily imply that the program failed to improve environmental performance, for two reasons. First, because participants tend to be the most noncompliant firms, achieving a rate of compliance similar to that of cleaner firms could still be considered an improvement. Second, because participants undergo more rigorous audits than nonparticipants, violations are more likely to be detected, which could explain the higher frequency of fines among them. Nevertheless, the negotiation process that allows plants to avoid penalties, combined with the subsequent inspection amnesty, may reduce the incentive to comply with environmental standards. The authors conclude that the program "provides carrots—namely certification and an inspection amnesty—that helped leverage […] enforcement sticks."

Crowding out mandatory standards. Second, the widespread adoption of voluntary standards may hinder the implementation of more stringent environmental policies, such as mandatory minimum standards. Felckinger and Glachant (2011) argue that firms and industries can use self-regulation strategically—exceeding existing regulatory requirements—to preempt the imposition of more stringent regulations. Firms adopt voluntary standards to deter legislative efforts exerted by policy makers to pass environmental laws that are unpopular within business circles. Similarly, Calveras, Ganuza, and Llobet (2007) and Ambec and De Donder (2022) highlight a "crowding-out" effect between voluntary and mandatory standards. In their political economy models, where regulation stringency is determined collectively by society, people may vote for weaker environmental regulations, relying on voluntary green standards. People effectively free ride on the abatement efforts financed by environmentally conscious consumers who pay a premium for greener products. As a result, the overall level of environmental protection is lower than it would be in the absence of voluntary standards.

Standards and trade: Minimal standards in developing countries

Environmental standards play a crucial role in shaping international trade, particularly for developing economies. While concerns are often raised about the potential effects of stringent environmental regulations in restricting trade, standards can foster trade by reducing transaction costs, improving product quality, and facilitating market access (Elamin and Cordoba 2020). In developing countries, the adoption of minimal but credible environmental standards can potentially help firms integrate into global value chains while addressing environmental externalities (Henson, Masakure, and Cranfield 2011).

Adopting more stringent standards to access foreign markets. When designing environmental standards for internationally traded products, countries may be motivated by gaining access to foreign markets. Surveys show considerable variation in public perceptions of environmental challenges, as well as in public views on the stringency of environmental regulations (ISSP 2023; OECD 2023). Public opinions differ widely on issues such as the use of pesticides or genetically modified seeds in agriculture, the use of nuclear or coal to generate electricity, and the potential impact of climate change—and these differences play out in the political arena. As a result, the optimal level of environmental protection is largely country-specific, with regulations varying significantly between countries which leads to a potential gap in regulatory stringency across countries.

However, access to foreign markets often requires adherence to more stringent environmental standards for exported products. One way to align domestic regulations with these foreign requirements is by adjusting environmental policies to mirror stricter foreign standards. Another option is to apply more stringent regulations exclusively to exported products. However, this approach necessitates a clear separation between domestic and export-oriented supply chains, with effective

traceability mechanisms to ensure compliance. The trade agreement between the Mercosur and the European Union reported in box 4 illustrates this trade-off.

Box 4. Environmental standards and the EU-Mercosur trade agreement

In June 2019, the European Union (EU) and the Mercosur area (Argentina, Brazil, Paraguay, Uruguay) signed a trade agreement. It consists mostly of a progressive reduction of tariffs on mutually traded products. Parties also agreed to meet annually in subcommittees to exchange views on topics that are regulated through standards: food safety, animal and plant health, antimicrobial resistance, biotechnologies, and animal welfare. The aim is "to strengthen their mutual confidence and agree to establish dialogues and exchange" (European Commission 2024a).

An evaluation report of the EU-Mercosur trade agreement, mandated by the French government (Ambec et al. 2020), highlights a significant gap between the environmental and sanitary standards of the two signatory parties. For instance, approximately 27 percent of the pesticides used in the Mercosur region are banned in the EU. Additionally, while crop-dusting is prohibited in the EU, it remains permitted in the Mercosur region. The EU also imposes stricter regulations to protect animals during transport.

The report mentions the challenges in enforcing stricter sanitary standards for imported meat, primarily due to the imperfect traceability of animals. Notably, the EU prohibits the use of hormones and beta-agonists for promoting bovine growth, and beef imported into the EU must meet this standard. However, a recent audit conducted by the European Commission in Brazil (European Commission 2024b) reveals that current procedures do not adequately ensure that cattle intended for the EU market are free from estradiol, a synthetic estrogen steroid hormone. This poses a significant risk because meat from such cattle could potentially violate EU health and safety regulations.

The disparity in standards has become a central argument among French farmers against the EU-Mercosur agreement, particularly in 2024. Farmers have expressed concerns about the additional costs they incur to meet stricter EU regulations—costs that their Mercosur competitors do not face. This creates an uneven playing field, they argue, resulting in unfair competition. Moreover, the laxer environmental and sanitary standards in the Mercosur undermine the EU's broader goals of protecting biodiversity and public health. The policy dialogue component of the EU-Mercosur agreement in subcommittees may facilitate the harmonization of standards. However, it is not clear that it will lead to an improvement in those standards.

Harmonization of environmental standards across countries can reduce non-tariff barriers to trade, making it easier for exporters to comply with a single set of requirements rather than navigating a complex web of regulations in different markets. However, this harmonization comes at a cost because it may reduce the competitiveness of producers in markets with less stringent standards. Along this line, Disdier, Fontagné, and Cadot (2013) provide evidence that harmonization of technical barriers between developed and developing countries, including environmental and sanitation standards, expands developing countries' trade with developed partners, but does so at the expense of trade between developing countries themselves.

Fostering technological transfers. Technological transfers linked to environmental standards offer a potential benefit for developing economies. When firms upgrade their processes to meet international standards, they often gain access to cleaner and more efficient technologies, which can lead to long-term productivity gains. Foreign direct investment and trade agreements that incorporate environmental provisions can further facilitate the diffusion of green technologies, helping to bridge

the environmental and competitiveness gap between developing and developed countries (Chen et al. 2024; Hanna 2010).

Foreign environmental policy. Discrimination based on environmental quality is an increasingly important issue in international trade. Consumers and policy makers in high-income countries are placing greater emphasis on products with lower environmental footprints, driving the growth of green procurement policies and trade restrictions tied to sustainability criteria. A notable example is the European Union's Carbon Border Adjustment Mechanism (CBAM), which imposes tariffs on certain products—such as aluminum, iron and steel, pesticides, and cement—based on their carbon footprint. Importers to the EU must report the carbon intensity of their products. Firms that have already implemented systems to measure their carbon emissions are better positioned to comply with these requirements, especially if their emissions are certified by a third-party as in ISO 14001 certification standards. Moreover, companies that successfully reduce their carbon intensity can gain a competitive advantage, potentially boosting their market share in the EU (Ambec 2022; Ambec, Esposito, and Pacelli 2024).

In sum, while internationally harmonized environmental standards impose costs and distort domestic policy, they also create opportunities for expanding trade and upgrading technology. Developing countries that proactively adopt and implement well-calibrated environmental standards are better positioned to compete in the evolving global environmental and trade policies.

Conclusion

Standards are essential tools for addressing environmental challenges and promoting sustainable development. By imposing technological constraints on production processes and products, or limits on pollutants and toxins, they help mitigate the adverse effects of economic activities on human health, biodiversity, and climate. While market-based instruments are more effective at incentivizing pollution reduction at a lower cost, standards remain an important component of the optimal policy mix. They are particularly suitable for dealing with local pollution and preventing environmental accidents. They are also easier to implement and enforce, which is particularly important in countries with low institutional capability. They are often more effective in reducing pollution at a lower cost when complemented with market-based policy instruments, such as subsidies, taxes, or emission trading schemes, or nudges. Subsidies can help support technological investments required to comply with standards. Tradable performance standards add flexibility, incentivize further reductions in pollution, and lower compliance costs. Emission taxes and cap-and-trade systems complement emissions caps in controlling the flow of pollutants crossing the jurisdictions where those caps are implemented. Pricing emissions reveals information about a firm's pollution abatement costs that can be used to better tailor standards.

Environmental standards can be voluntary rather than mandatory, placing them within the category of information-based policy and behavioral nudges. Certification of environmental management systems and eco-labels provide valuable information to investors, companies, and consumers who are concerned about the environmental impact of their decisions. Empirical evidence shows that firms can gain a competitive advantage by adopting voluntary standards. These standards can also help overcome resistance from powerful lobbies opposing stricter regulations. However, their environmental impact is often limited because the voluntary standards are weak (for example, firms engage in greenwashing), and they deter the adoption of more stringent standards (such as stricter minimum mandatory standards).

Environmental standards play a significant role in shaping international trade, especially for developing economies. Countries might be tempted to align their own standards with foreign market

requirements to enhance market access, especially when deficient product traceability along the supply chain prevents them from limiting the imposition of foreign standards only to their exports. Harmonizing environmental standards can reduce trade barriers but may undermine competitiveness, particularly for producers in less regulated markets. Additionally, harmonization could conflict with public opinion, as views on environmental issues vary significantly across countries. Technological transfers linked to environmental standards offer long-term benefits by helping firms access cleaner technologies, attract demand for sustainable products, and comply with trade policies such as the EU's Carbon Border Adjustment Mechanism.

Notes

[1] Market-based instruments are sometime referred to incentive-based instruments (Goulder and Parry 2008) because they incentive reduction of pollutants through monetary transfers.
[2] Carbon dioxide equivalent (CO2e) includes other greenhouse gases besides carbon dioxide.
[3] This third category of policy instruments is also referred as “non-monetary” instruments because these instruments incentivize reduction of pollutants without any monetary transfers.
[4] The ISO 14000 family of regulations, developed by the International Standardization Organization (ISO) is a set of international standards for environment management systems. Refer to iso.org.

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