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ENVIRONMENTAL REGULATION: LESSONS FOR DEVELOPING ECONOMIES IN ASIA

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Abstract

Developing countries in Asia face a variety of environmental challenges. Although environmental economics grew mostly out of the experience of developed countries, decades of environmental economics research offer important and useful lessons for environmental regulation in developing countries in Asia. We synthesize the theoretical and empirical literature on environmental regulation and highlight important insights on formal regulation such as taxes, standards, and tradable permits, as well as on informal regulation such as information and voluntary approaches. We also discuss directions for future research.

Contents

1. INTRODUCTION

Asia faces daunting environmental challenges. A recent UNEP report finds that about 4 billion people or over 92% of the population in Asia and the Pacific are exposed to air pollution exceeding or far exceeding WHO guidelines (UNEP 2019). Some of the challenges arise from rapid industrialization, as evidenced by the severe air, water, and soil pollution in the People's Republic of China (PRC) and India, and some arise from economic development leading to resource degradation, e.g., deforestation and loss of biodiversity in Southeast Asia. Despite the diversity in the nature, drivers, and possible solutions of environmental pollution across the nations in Asia, there are lessons about environmental regulation learned from decades of research and practice that can be useful for many Asian countries. The purpose of this paper is to identify such lessons, discuss their theoretical background and practical applications, and explore their implications for Asia.

I will start by qualifying what this paper does *not* do. First, Asia is large, with almost 50 countries and regions having all or some of their territories in the continent. The paper does not even attempt to cover the details of environmental regulation in any single country. Second, Asia is heterogeneous in its stages of economic development, but the majority of Asian countries are developing economies. I will thus focus on lessons of environmental regulation for developing countries, while noting that there are developed economies (such as Japan) and oil-rich countries (such as Saudi Arabia) that face unique environmental challenges. Third, although there has been extensive research on environment and development,[1] most of the review papers have focused on the empirical side (e.g., Vincent 2010; Blackman 2010; Pattanayak, Wunder, and Ferraro 2010; Somanathan 2010; Blackman, Li, and Liu 2018). Although I will discuss both the empirical and the theoretical findings that are relevant for developing countries, most of the cited literature covers empirical findings.

Pollution is an environmental externality for which markets do not exist and thus polluters do not receive proper price signals that otherwise would steer their behavior towards socially optimal levels. This market failure calls for intervention, often by the government, to correct the externality. The bulk of economic research on environmental regulation deals with two issues on how to correct the externality: (i) the type of regulation, i.e., instrument choice among taxes, standards, and tradable permits; and (ii) the stringency of regulation, i.e., the appropriate levels of the instrument once it is chosen. Besides these top-down government regulations, there is considerable research on bargaining in economic theory that is relevant for pollution control, and more recently there has been growing research on informal regulation such as releasing information about firms' environmental performance and voluntary approaches where firms engage in environmentally friendly behavior without an explicit requirement by the government. My discussion will focus on instrument choices in formal regulation and how they can be complemented by informal regulation.

The core economic theory of environmental regulation was advanced in the context of developed economies. Some of the fundamental and often implicit assumptions underlying the theory are violated in developing countries, limiting the applicability of the theoretical findings. For example, although market-based instruments such as permit trading are often adopted in developed nations, many developing countries lack the capacity to quantify historical emissions of firms, making it difficult to determine the initial

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[1] An academic journal, *Environment and Development Economics*, is devoted to this subject, and *Review of Environmental Economics and Policy* published a special issue in 2010 (Volume 4, Issue 2) devoted to environmental quality and economic development.

grandfathered allocations of permits. Further, even for thick markets where there are many polluters with large potential for permit trading, there might be a lack of market makers so that transaction costs cannot be reduced quickly. In discussing the theoretical findings, I will highlight the main assumptions and critical conditions that are needed for the findings to hold, show how some of the conditions are violated in developing country settings, and discuss which lessons are relevant for environmental regulation in developing countries.

The rest of the paper is organized as follows. In Section 2, I discuss the main components and findings of the economic theory of environmental regulation, and the (often ideal) conditions under which the findings hold. I move on to discuss the special characteristics of developing countries in Section 3, and the lessons learned about environmental regulation in these countries due to these characteristics in Section 4. I will conclude in Section 5.

2. A PRIMER ON THE ECONOMICS OF ENVIRONMENTAL REGULATION

A core argument of neoclassical economic theory is that free markets can allocate scarce resources in a Pareto efficient way under a set of ideal conditions including perfect competition and the absence of externalities. In this ideal world, the role of the government is limited to ensuring property rights and free competition. However, free markets fail to be efficient in the presence of pollution externalities, and the field of environmental economics is largely devoted to finding ways to correct or internalize such externalities, with most of the approaches involving an active role on the part of the government. The market failure is illustrated in Figure 1, which compares the market outcome with the socially optimal allocation. Suppose a firm emits pollution in its production process, with the emission level represented on the horizontal axis. From the firm's perspective, it chooses emission E_{self} to equate the marginal benefit from emission MB (e.g., marginal profit from increased output) with its own marginal cost MC_{self} (e.g., the marginal cost of using more coal). However, the pollution causes damages to the society, so that the social marginal cost MC_{all} is higher than MC_{self}, and the optimal social emission E_{all} is lower than E_{self}. Competition in the presence of pollution externalities leads to too much pollution.

Figure 1: Market Failure Due to Pollution Externalities
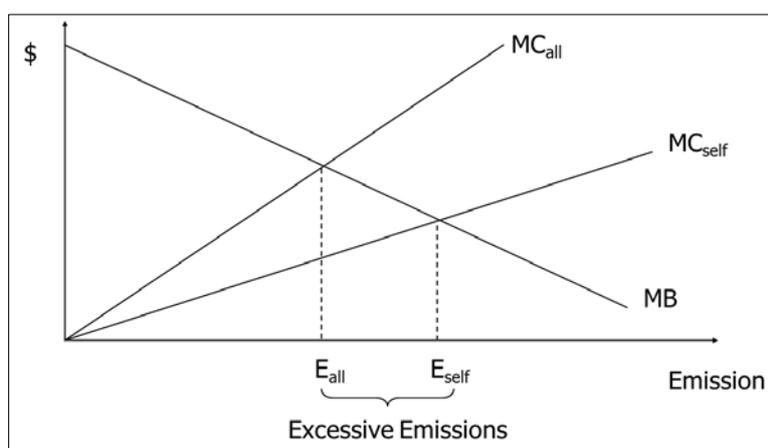
The environmental economics literature has studied five main approaches to correcting the externalities, with varying degrees of government involvement. These include pollution standards, Pigouvian taxes, tradable emission permits, Coase bargaining, and informal regulation such as information and voluntary approaches. Policies in practice are often combinations of these instruments, but understanding the pros and cons of each is important in assessing the potential effects of these hybrid policies. We will discuss each of these regulatory instruments, but we start by describing the criteria that have been proposed to compare them and to choose the optimal regulatory approach among them.

2.1 Criteria of Instrument Selection

Economic theory has primarily focused on two main criteria in choosing the level and format of environmental regulation. *Social optimality or efficiency* is a first-best criterion whereby the regulation is chosen to maximize social welfare, which in ideal conditions (e.g., no uncertainty, no information asymmetry, and no transaction costs) requires equating the marginal damage of pollution with the marginal cost of abatement. In Figure 1, a regulation would have to achieve the socially optimal emission level of E_{all} with minimum cost in order to be socially efficient. Applying this criterion requires having sufficient information on the marginal damages and costs, which is difficult to obtain.[2] Economists thus often resort to a less demanding second-best criterion of *cost effectiveness*, which requires minimizing the total costs of achieving a certain pollution level, while noting that the pollution level might not be socially optimal. In Figure 1, a regulation will be cost effective if it reduces emission from E_{self} to a lower level *at minimum costs*, but not necessarily to E_{all}. Cost minimization is achieved if the marginal abatement costs are equalized across all polluting firms; otherwise, the total abatement cost can be reduced by making a high-cost firm abate less while a low-cost firm abates more.

Additional criteria have been proposed to evaluate the desirability of regulatory approaches, including incentives for pollution firms to adopt new abatement technologies, and administrative costs that include multiple components, such as regulatory simplicity, information requirement, transaction cost of implementation, etc. Given that environmental regulation is mostly at levels lower than socially optimal, it has been argued that environmental regulation should aim to encourage the innovation and adoption of new abatement technologies (Zhao 2003). This criterion has sometimes been called "dynamic efficiency," in contrast to the "static" efficiency discussed above. Market-based approaches such as taxes and tradable permits have been found to provide more incentives than standards, by putting less restrictions on what firms can do (including adopting new technologies). On the other hand, as we show below, standards have the advantage of having lower administrative costs, by requiring less information and reducing the complexity of transactions, than taxes and tradable permits. Finally, instrument choices can be affected by the institutional settings of a country. Ye and Zhao (2016) show that in countries with public firms contributing to pollution, the promotion incentives of public firm CEOs can be important in influencing the choice of optimal policy instruments.

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[2] The bulk of empirical research on the costs of pollution, e.g., that studying the health effects of pollution, focuses on obtaining values related to the *total* value of pollution damages rather than marginal damages (e.g., Currie et al. 2014; Ebenstein 2012). Nonmarket valuation methods, especially revealed preference methods such as travel cost models and hedonic price models, have been used to study the value of improved environmental quality, but the focus has not been on identifying marginal damages (Kling, Phaneuf, and Zhao 2012).

Despite the large literature about these criteria, they have not always been influential in practical policy making, especially in developing countries. In fact, the less studied criteria of administrative costs are often more important for developing nations (O'Connor 1999). In this paper, I will emphasize the practical applicability of these criteria rather than their theoretical appeal. As such, I will not discuss one criterion, as proposed by Weitzman (1974), that has been influential in academic research on choices between tax and tradable permits under uncertainty and asymmetric information. The criterion requires information about the slopes of marginal benefit and marginal cost curves in Figure 1, which is extremely difficult to obtain.

2.2 Command-and-Control Approach: Standards

The most commonly used regulatory instrument, especially in developing countries, is emission standards – they are imposed on firms and differ from ambient environmental quality standards. There are different kinds of standards: Absolute standards cap total emissions by polluting sources; performance standards limit emissions per unit of output or input; and technology standards specify the equipment, processes, or inputs firms have to use (Helfand 1991). In Figure 1, an absolute standard could be imposed on firms so that each emission is capped at a level lower than E_{self}. The European emission standards for vehicles, which serve as a benchmark for many countries in Asia (e.g., in heavily polluted cities in the PRC and India), are performance standards that limit the amount of air pollutants emitted per kilometer driven for certain vehicle types. Standards are the main forms of *command-and-control (CAC) approaches* where the government simply limits what firms can do as opposed to *market approaches* where the government provides financial incentives to influence firm behavior, although violators of standards also face hefty fines.

Standards have the advantage of being relatively intuitive, straightforward, and transparent: If firms cause pollution, it makes intuitive sense to restrict their behavior. They often seem fair, in the sense that polluters causing harm to the environment are restricted in their behavior, and such restrictions are uniformly imposed on all polluters. Standards are typically imposed on new firms, which can sometimes become significant entry barriers for new firms, thereby protecting the interests of existing firms. These features help standards become more politically feasible than other instruments. The Corporate Average Fuel Economy (CAFE) standard is adopted in the US partly because the first-best tool of taxing gas emissions is politically infeasible.

Compared with taxes and permit trading, standards target observable behavior and thus require less effort in terms of monitoring and enforcement. It might be difficult to monitor actual firm-level emissions but it is much easier to observe whether a firm has installed certain abatement equipment, or to track its use of dirty inputs such as coal. Thus, when taxing actual emissions is infeasible, the government can impose technology standards on equipment use or input standards. This is extremely important for developing countries, where the monitoring of emissions is typically inadequate and could be a major reason why many developing countries adopted standards as their primary regulatory approach.

Another main reason for the widespread adoption of standards is that they can bring observable environmental improvements quickly. Most environmental standards in the US were adopted in the 1970s when the government wished to obtain quick and big environmental improvements in response to serious pollution (Portney 2000). In developing countries, Blackman, Li, and Lilu (2018) find that CAC approaches (mainly standards) have worked better than market-based approaches in bringing environmental

improvements. Environmental campaigns in the PRC mostly take the form of new standards or more enforcement of existing standards (Van Rooij 2006).

Despite their widespread use, standards suffer from a major drawback: They are neither efficient nor cost effective because uniform standards are imposed on heterogeneous firms. Firms are heterogeneous in many aspects, leading to them facing different abatement costs. They should thus undertake different levels of abatement, with low-cost firms abating more and high-cost firms abating less. Standards, by failing to attend to such heterogeneity, can be extremely costly. During the 1990s, the US removed a number of standards imposed on its major power plants and replaced them with an SO2 permit trading program. During the early phases of the program, permit trading was sporadic, but the abatement costs went down by as much as 50%, due to the flexibilities the power plants enjoyed thanks to the removal of the rigid standards (Carlson et al. 2000). Among the instruments available, standards also provide the least incentive for innovation and adoption of low-abatement technologies. Because of the lack of static and dynamic efficiency, economists have argued for a long time in favor of moving away from standards in environmental regulation.

2.3 Pollution Taxes

Figure 1 indicates that the reason why firms do not internalize pollution damages is that they do not have to pay for the emissions. In other words, there is not a price signal for the emissions that guides firm behavior, as in what happens with other market-traded goods. A "natural" solution is to provide such a price signal through what is known as a "Pigouvian tax." In Figure 2, a tax t on emissions that equals the difference between the social marginal MC_{all} and the private marginal cost MC_{self} at the socially optimal emission level E_{all} can restore the first best. Now the firm's marginal cost of emissions equals $MC_{self} + t$, and when equating it with the MB curve, it will choose its emission at the socially optimal level. Even when the tax does not equal the wedge between the two marginal cost levels, Pigouvian tax is cost effective, because every firm will choose emission so that its marginal abatement cost equals the tax level, implying that the marginal costs are equalized across all firms. Further, it can be shown that the tax policy also provides higher incentives than standards for firms to adopt new abatement technologies. In sum, taxes dominate standards because taxes are always cost effective, and can be both statically and dynamically efficient.

Emission taxes have another advantage if the tax revenue is used to reduce other distortionary taxes, leading to double dividends (Goulder 1995; Bovenberg 1999). Most taxes, such as income tax and sales tax, are distortionary and lead to misallocation of resources. Pollution tax is not distortionary since it provides the "correct" market price. If the tax revenue is used to (partly) satisfy the government's budget needs, there is less need for other distortionary taxes for revenue purposes. The double dividend hypothesis argues that doing so is desirable because social welfare can be improved by having lower and fewer distortionary taxes.

One of the main difficulties facing pollution taxes is that emission levels need to be measured relatively accurately for each individual polluter – this is not a trivial task in developing countries. Another difficulty arises from the public's resistance to taxes and political economy considerations. The resistance varies across countries, and depends on both the political landscape and the governance capacities. Tax revenues can also lead to corruption incentives. Nevertheless, pollution tax is often the policy instrument most widely promoted by economists.

Figure 2: Pigouvian Tax Internalizes Externalities
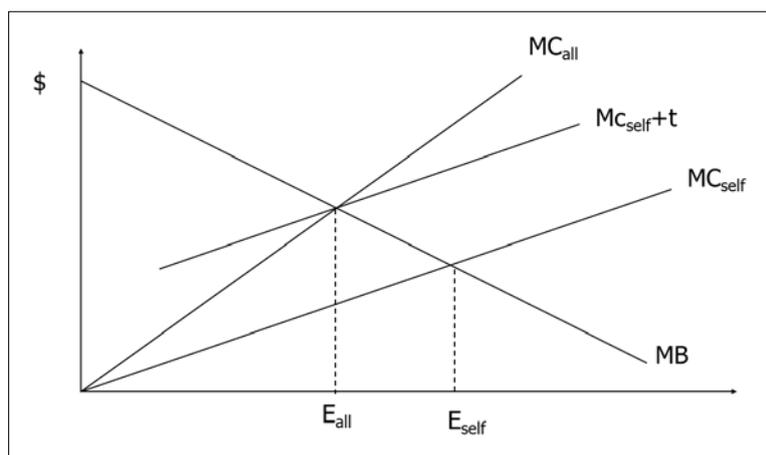
2.4 Tradable Permits

Fundamentally the lack of price signals for emissions is because there is no market for emissions. As suggested by Montgomery (1972), such a market can be created through the government issuing permits for emissions and the firms engaging in permit trading. In a tradable permit scheme, a firm's emission cannot exceed the number of permits it holds. The government first *caps* the total emissions by determining the total number of permits distributed to the firms, and then the firms can *trade* the permits in a market. The *cap-and-trade* approach has gradually gained popularity since the US launched the SO2 trading program in 1990, with the European carbon market, EU ETS, being currently the largest permit trading market in the world.

Permit trading has several desirable features. First, it is always cost effective. Through permit trading, all firms face the same permit price, which they will equate with their own marginal abatement costs. The result is that the marginal costs are equalized across all firms. Second, permit trading can be efficient if the total number of permits equals the socially optimal pollution level, i.e., E_{all} in Figure 1. Third, permit trading provides strong incentives for firms to adopt new abatement technologies – as strong as those provided by taxes under most conditions. Thus, it can achieve dynamic efficiency. Fourth, the cost effectiveness and efficiency features are independent of how the permits are allocated, e.g., through grandfathered or auctioned permits, or through permits evenly or unevenly distributed to the firms. This feature helps permit trading to be more politically feasible as initial permit allocation can be used to gain political support.

Tradable permits, as an example of market-based approaches, dominate emission standards in that they are both quantity policies, i.e., policies that restrict total emissions, but the former provides enough flexibility to achieve cost effectiveness while the latter is much more rigid. As such, permit trading has been promoted by economists in many settings beyond pollution control. For example, tradable catch quotas have been promoted by economists and adopted by many fisheries as an effective way to limit fishing in a cost effective way.

For tradable permits to work, two fundamental conditions are needed. One is clear definition and protection of property rights, in that firms have to have permits in order to emit and the permits are private properties. The second is that the market needs to be "thick" enough, i.e., the number of participants has to be high enough, so that the transaction costs of permit trading are sufficiently low. A thick market is needed for

market makers to step in to make transactions. In the US, there are many local and regional water trading markets that failed largely due to the limited number of participants (Garrick 2015).

2.5 Coase Bargaining

The government plays a central role in the three regulatory instruments discussed above. When there are a small number of polluters and victims, Coase (1960) argues that the government does not have to be directly involved in restricting emissions. Instead, all it needs to do is to clearly define the property right structure, namely whether the polluters have the right to pollute or the victims have the right to a clean environment. The polluters and victims can bargain towards an efficient solution. For example, if the victims have the right to a clean environment, the firms can "bribe" or "compensate" the victims by offering them a price higher than the marginal damages from the pollution. In Figure 1, at any emission level that is lower than E_{all}, the marginal cost (or damage) suffered by the victims from emission is lower than the firm's marginal benefit from emitting the pollutant. In this case, a price can always be found between the marginal cost and marginal benefit, so that the victim is willing to be compensated at the price (since it exceeds the marginal damage of pollution to them), and the firm gains from being able to emit more by paying the price for its emission (since the price is lower than its marginal benefit from emission).

Although Coase's argument is intuitive, its conclusion is sensitive to a number of implicit assumptions and simplifications, such as complete information about the marginal costs and benefits, low transaction costs in bargaining towards an efficient solution, and ambiguity about the bargaining setting. The large literature on bargaining has shown that the conclusion breaks down when there is asymmetric information, in which case the outcome is sensitive to the bargaining institutions (Muthoo 1999). More importantly, the transaction costs can become prohibitively high if there are many polluters and victims, which is usually the case in environmental regulation.

Nevertheless, when formal environmental regulation is insufficient and when pollution is concentrated in a small area, bargaining between the victims and polluters can reduce pollution. As we discuss later, this has happened in Asia, and can be a supplement to formal regulation.

2.6 Informal Regulation through Information and Voluntary Measures

In recent years, there has been increasing interest in studying nonregulatory approaches towards reducing pollution, with the literature focusing on two areas, namely dissemination of firms' environmental performance to the public and firms voluntarily reducing their emissions. Information and voluntary programs started in developed nations and gained popularity in recent years as a way to supplement formal regulation, in many cases to encourage over-compliance with existing regulations (Koehler 2007; Morgenstern and Pizer 2007). Part of the reason behind the rise of these informal approaches is increased public awareness and concern about the environment that has translated to green market forces. It might thus pay to reduce emissions, as greener products might get higher prices and green practices can lead to stock market rewards. Conversely, heavy polluters will get punished in the marketplace. Figure 1 shows that these approaches effectively raise the private marginal cost of emissions, MC_{self}, so that firms find it optimal to reduce their emissions.

Public dissemination of firms' environmental performances, such as their emissions, might work both because public images matter in the marketplace and because the resulting public pressure might cause regulators to target heavy polluters for enforcement. Konar and Cohen (1997) find that mandatory disclosure of firms' emissions through the Toxic Release Inventory (TRI) in the US caused some firms' stock values to decline after the release of information, and these firms subsequently reduced their emissions in response. Stock markets penalize heavy polluters when the information is made public either because investors expect market responses to the firms' products and/or because of the threat of targeted enforcement. Bennear and Olmstead (2008), using data from water utilities in the US, show that requiring the utilities to disclose water quality violation information to their customers is effective in reducing total violations, and this is especially true for larger utilities. Public utilities are regulated entities, and their response to information dissemination might be due to expectations of regulatory responses. In Asia, Arimura, Darnall, and Katayama (2011) show that environmental certificates such as ISO 14001 are effective in improving green supply chain management.

One benefit of information dissemination that has been less studied is that public information about firms' emissions allows the victims to take more appropriate defensive measures (Evans, Gilpatric, and Liu 2009). For this purpose, the most important piece of information is the ambient pollution levels, rather than emissions from individual firms.

Firms have a number of incentives to undertake voluntary measures to reduce their emissions. Lyon and Maxwell (2008) list demand-side forces due to the public's increasing awareness and valuation of green products and practices, supply-side forces due to product differentiation and potential cost savings, and public policy forces due to current and potential regulation. Ambec and Lanoie (2008) show that firms can gain from improving their environmental performance through several channels, including better access to more environmentally demanding markets, being able to differentiate their products from others, gaining competitive advantages in pollution control technologies, and savings on materials and energies. Albertini (2013) reviews 52 studies over a 35-year period and finds that there is a positive relationship between firms' environmental performance and their financial performance, and this relationship is influenced by the specific performance measures used. Earnhart (2018) reviews the empirical literature on the effects of environmental performance on firms' financial performance, and finds that in general there is a positive relationship but it is sensitive to how the financial performance is measured. However, voluntary programs do not always create win-win situations for the environment and for the firms' bottom line. Fisher-Vanden and Thorburn (2011) find that firms suffered reduced stock returns after they joined the US EPA's Climate Leaders, a program of voluntary greenhouse emission reductions.

3. CHARACTERISTICS OF ENVIRONMENTAL REGULATION IN ASIA'S DEVELOPING COUNTRIES

Although Asian countries are diverse in their environmental challenges and responses, there are some patterns that are shared by many of these countries. For important pollutants such as particulate matter, ozone and NO_2, most of these countries have ambient quality standards that are less restrictive than, but structurally similar to, the World Health Organization (WHO) guidelines. Figure 3 shows a comparison of ambient standards of $PM_{2.5}$ and PM_{10} (Panel a), and of ozone and NO_2 (Panel b), for the WHO

versus a sample of Asian countries.[3] Most of the standards are less stringent than the WHO guidelines, and there is a certain degree of similarity in terms of the stringency of the standards across the countries. For example, a number of countries have adopted a PM_{10} 24-hour standard of 100 or 150 $\mu g/m^3$, in contrast to the WHO guideline of 50. Another common feature is that, despite the relatively lax standards, they are often violated by almost all of these countries. Figure 4 shows the population weighted annual $PM_{2.5}$ exposure from 1990 to 2017 for our sample countries. Except for Indonesia, Malaysia, and the Philippines, the standards are violated by all other countries, with India, the PRC, and Bangladesh far exceeding their standards.

A natural question, then, is how to better govern the environment in these countries. Much of the economic theory on environmental regulation grew out of experiences in developed countries. This is reflected in the fact that the bulk of the theory is devoted to studying instruments that are either socially efficient or cost effective, with the implicit assumption of adequate capacity for monitoring and enforcement, benevolent social planners, and efficient markets, with environmental externalities being the only market failure. Although these assumptions seem ideal even for developed countries, they are often violated to a much larger degree in developing countries. Below we discuss the main departures from these assumptions in developing countries – they will form the basis for understanding and guiding Asia-specific environmental policies.

Limited capacity for monitoring and enforcement. Perhaps the biggest challenge facing developing countries is insufficient capacity for monitoring regional ambient concentrations of major pollutants but especially of emissions of individual firms. Accurately monitoring ambient concentrations is the first step in environmental regulation because environmental quality targets of national policies are often expressed in ambient concentrations of major pollutants. For some air pollutants such as particulate matters, satellite data are increasingly available to help monitor ambient concentrations, but for most other pollutants, adequate monitoring requires locally installed equipment and professionals to operate it, and collect and disseminate data. A major achievement of the US EPA since its creation in 1970 is a well-functioning nationwide air quality monitoring system, which forms the backbone for the National Ambient Air Quality Standards (NAAQS). However, adequate monitoring of ambient pollution is far from being sufficient for effective regulation, which requires monitoring of firm-level emissions. Without firm-level data, point source pollution is turned into nonpoint source pollution, and it is well-known that nonpoint source pollution is difficult to control because it is difficult to hold individual polluters responsible for their emissions (Shortle and Horan 2001). For nonpoint sources, either firms are not regulated or regulation takes the form of rigid standards on observable activities such as equipment and input use. For example, small-scale polluters in the PRC are often forced to shut down instead of being required to pay emission fees as large firms do (Ma and Ortolano 2000).

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[3] Not all countries have the same types of standards as the WHO guidelines. For example, Cambodia has standards on TSP, but not on $PM_{2.5}$ or PM_{10}.

Figure 3: Ambient Air Quality Standards of Selected Asian Countries versus WHO Guidelines
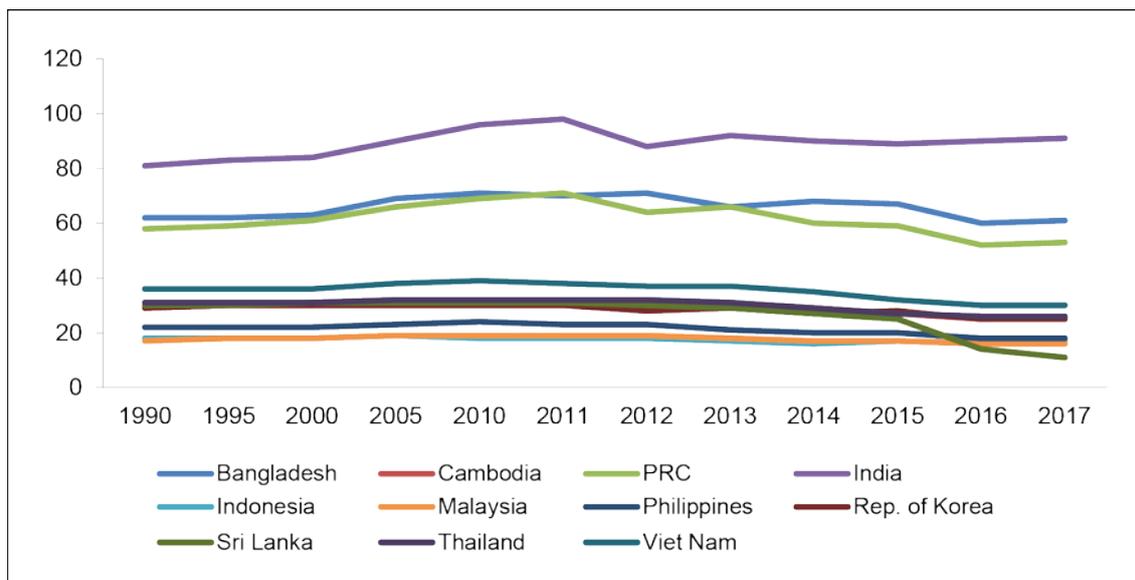
Panel a: Ambient standards on particulate matters
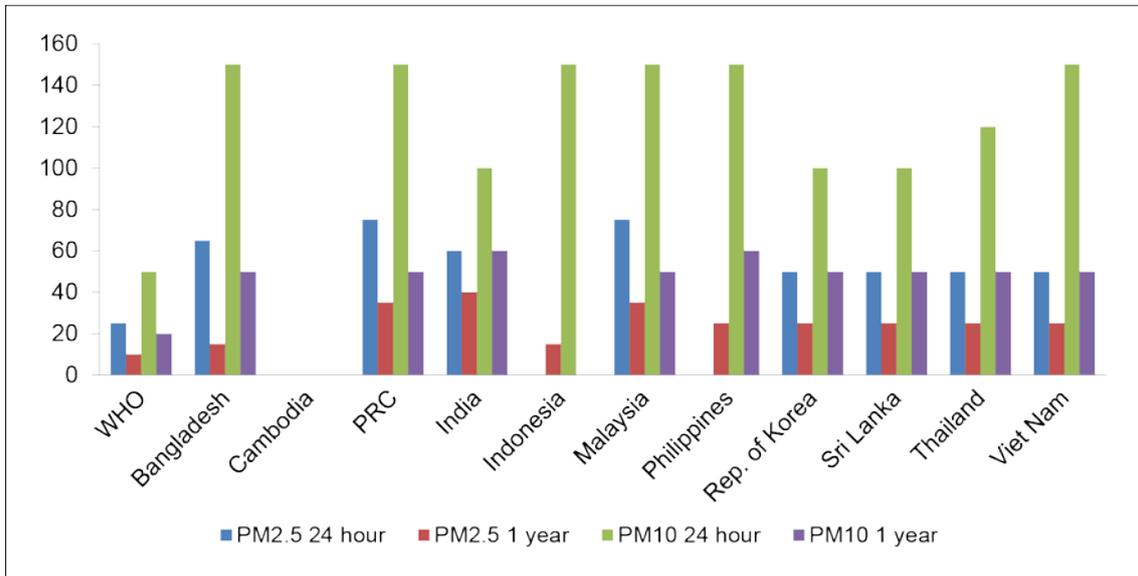
Panel b: Ambient standards on ozone and NO$_2$
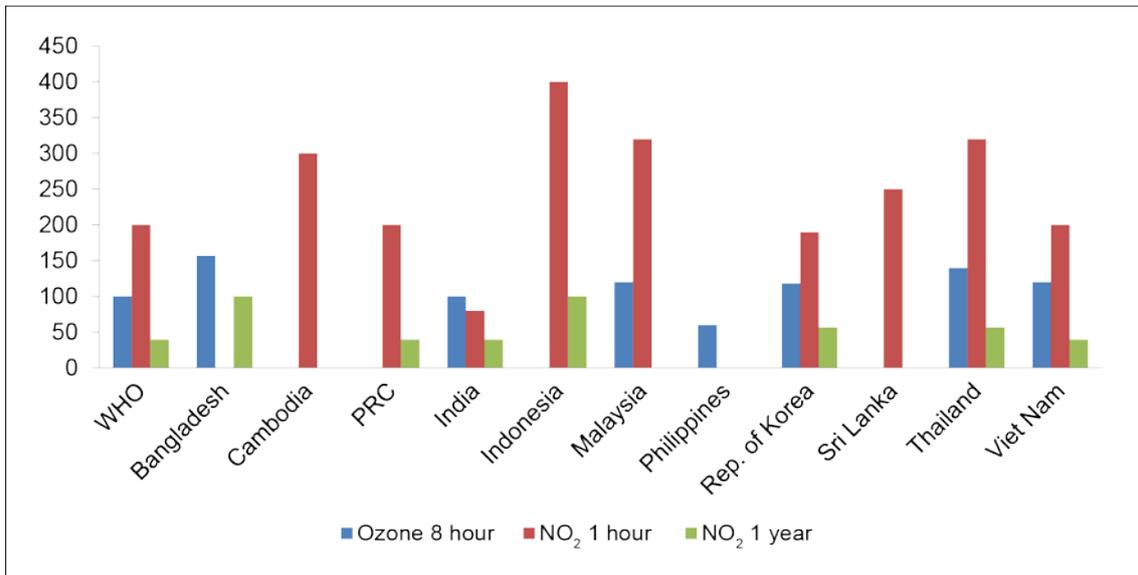
Data sources: Joss et al. (2017), CAI-Asia Center (2010a, 2010b), and UNEP (2019).

**Figure 4: Population-weighted Annual PM$_{2.5}$ Exposure
of Selected Asian Countries**

Developing countries also tend to lack adequate capacity for enforcement, which is closely related to monitoring. Enforcement is much more than having the personnel and funding to support environmental agencies; it involves governance structures, legal systems for both civil and criminal cases, and incentives provided for enforcers. In the PRC, for example, local environmental protection agencies report both vertically to the Ministry of Ecology and Environment (of the central government) and horizontally to local governments, resulting in compromises in enforcement efforts when local governments prioritize economic growth. Many developing countries lack adequate legal systems for citizens to bring civil or criminal lawsuits against polluters. Furthermore, corruption often undermines the incentives of government officials to enforce environmental laws and regulations.

Environmental protection and economic growth. Economic development and growth are central concerns of developing countries, and in recent years many of Asia's developing countries have experienced periods of rapid economic growth, often at the cost of the environment. Although economists often argue against the "pollute first and clean up later" approach, there is no firmly established theory on the optimal pollution path that is applicable to all developing countries. The environmental Kuznets curve (EKC), as an empirical summary of the past experiences of many countries, predicts that environmental quality falls first and rises later as a nation grows its economy (Dasgupta et al. 2002). However, the EKC does not offer guidance on effective regulatory approaches and on how growth and environmental protection should be related to each other.

An often neglected aspect in the growth-environment debate is that environmental regulation is more likely to hurt economic growth if it is not efficient or cost effective. A case in point is the backlash against government efforts to reduce coal used for heating in the north of the PRC during the 2017–2018 winter season (Bradsher 2017). To meet air quality goals, some local governments took extreme command-and-control measures to shut down a large number of factories and coal-based heating devices for schools and families. Although effective in improving air quality in the short term, such

regulatory approaches can contribute to the argument that environmental regulation is economically costly, possibly leading to less public and private effort to reduce pollution in the long run. It is precisely because countries are concerned about economic growth that they should be careful to design and implement environmental regulation that is at least cost effective. Economic growth should be an argument for market-based regulatory approaches, rather than an argument against pollution control.

Market and regulatory distortions. No market is perfectly competitive and environmental regulation always coexists with other types of regulations. There is a sizable literature on environmental regulation when the output market or the permit market is characterized by market power (Kennedy 1994; Requate 2006). Most of the findings are concerned with adjusting the levels of the policies, such as the tax level or the distribution of permits, so as to reduce the distortions caused by imperfect competition. Although there is no consensus, imperfect competition does not seem to favor one type of policy instrument over another. These observations also apply to environmental regulation facing other distortionary government policies. If the government subsidizes industrial growth that causes pollution, any regulation that tries to reduce the pollution will interact with the subsidy policy. When multiple distortions coexist, it might be desirable to use a mixture of policies to correct the environmental externalities, with some policies directly targeting pollution while others deal with the interactions with other policies (Bennear and Stavins 2007; Lehmann and Gawel 2013). For example, Wang, Zhao, and Bhattacharya (2015) consider an economy facing both pollution externalities and a lack of adequate health insurance – a situation that applies to many Asian developing countries. Economic growth causes pollution, which in turn raises health risks. Without adequate health insurance, individuals make precautionary savings to prepare for an increased likelihood of being sick at an older age. The higher savings rate leads to more economic growth and more pollution, leading to a vicious cycle of growth – pollution – savings – growth. The authors find that the optimal intervention needs to include a combination of environmental, health, and social redistribution policies.

Top-down versus bottom-up approaches. Most countries in Asia have government-centered environmental institutions: Governments play much larger roles than NGOs and the civil society in environmental protection, and environmental activism and consumers' environmental attitudes play relatively limited roles. These observations are especially true in East Asia (Shin 2015). As a result, formal regulation tends to be more important in Asia than in other parts of the world. For informal regulation to be more effective, Asian countries need to first improve their formal regulation, including its enforcement. The top-down approach also implies that regulatory tools such as pollution taxes might have an easier time being adopted than others in countries such as the US. There should be reasons other than political feasibility, e.g., economic efficiency and firms' tax burden, to justify the use of cap-and-trade instead of pollution taxes. The debate on double dividends, especially the argument for recycling pollution tax revenues to reduce other distortionary taxes, becomes especially relevant and important for Asian countries.

4. LESSONS FOR ENVIRONMENTAL REGULATION IN ASIA'S DEVELOPING ECONOMIES

In this section, I discuss the findings in the economics literature on environmental regulation that are relevant for developing countries in Asia. I have drawn mostly from the theoretical literature in the previous sections, but in this section, I will emphasize the empirical literature. A number of papers review environmental policies for specific countries and regions. Ma and Ortolano (2000) provide a comprehensive review of the PRC's environmental policies during the early stages of their development; many of the structures discussed still remain valid today. He et al. (2012) review the history of environmental regulations in the PRC and show that although the majority of environmental regulations are command-and-control policies, there is increasing adoption of market-based approaches such as green credits, emission charges, emissions trading, ecological compensation, and voluntary and information approaches. Auffhammer and Gong (2015) review the PRC's regulation of carbon emissions and particularly its experiments with the regional carbon markets. Divan and Rosencranz (2001) review environmental laws and regulations in India. Tan (2004) provides a brief review of environmental laws in Southeast Asia. O'Connor (1999) reviews the adoption of various forms of regulatory instruments in many countries including Asia.

4.1 Regulatory Process and Capacity Building

Often the first step in environmental regulation is to set the environmental quality targets for a country and for various regions. Such ambient standards specify the target levels of environmental quality, often expressed as maximum intensities or concentrations of certain pollutants. For example, almost every country has national or regional ambient air quality and water quality standards. Economic theory argues that, as shown in Figure 1, such standards should be set to balance the benefits of a clean environment against the costs of reducing pollution. However, fully implementing this criterion of maximizing social welfare requires information on the social benefit and cost functions, which is difficult to obtain. Instead, protection of human health has often been used as the single most important criterion in setting such goals. The standards set by the World Health Organization offer the most commonly used benchmark, and typically developing countries set their own ambient standards at levels similar to or lower than the WHO levels. For example, the 2005 WHO air quality guideline value for ozone is 100 $\mu g/m^3$ (8-hour mean), but the air quality standard in the PRC's urban areas is 160 $\mu g/m^3$ (8-hour mean), while it is about 128 for the Republic of Korea and 140 for Thailand. Similarly, the WHO guideline value for PM2.5 is 25 $\mu g/m^3$ (24-hour mean), but the standards are 75 for the PRC, and 50 for the Republic of Korea and Thailand. These more lax ambient standards are often violated, showcasing the severity of Asia's pollution problems.

The next step is to make and enforce laws and regulations to meet the ambient environmental quality standards. Ultimately environmental quality depends on the degree to which polluters are incentivized to reduce their emissions, so the law and regulations should target polluter behavior. A key requirement for successful enforcement is observability: The target behavior should be observable, measurable, and verifiable, either directly or indirectly. This is where capacity building is most needed, to be able to measure important behavior and to enforce regulations based on the measured behavior. Increasingly citizens are involved in the process of monitoring and reporting heavy pollution and environmental accidents, mostly on local scales (Martens

2006). Citizen participation can also be important in pushing actions by both government agencies and polluters.

Although specific regulations might be different, the regulatory processes are similar between developed and developing countries. For example, the PRC's environmental regulations, including the types and levels of environmental quality standards, are similar to those in the US and the European Union. In this regard, developing countries can learn from developed nations in regard to regulatory capacity building. For transboundary pollution, harmonized monitoring methods also serve to help form and enforce international environmental agreements. For example, international climate negotiations have always included the stipulation of helping developing countries build up their capacities in monitoring and accounting for greenhouse gas emissions.

4.2 Lessons about Formal Regulation

A number of important lessons have been learned from the empirical literature on environmental regulation. Before we discuss the specific lessons learned about the specific regulatory instruments, we discuss some general guidelines.

First, cost effectiveness is a more reasonable goal than social efficiency in guiding regulatory choices, but ultimately efficiency should be the grand goal. To achieve efficiency, more information is needed to estimate the economic damages from pollution, including health damages and productivity losses. The economics profession has developed sophisticated nonmarket valuation methods to estimate both the use value and the existence value of a clean environment, and there are increasing applications of these methods in developing countries, especially in the PRC and India. The bulk of the empirical nonmarket valuation literature values pollution and the environment in developed countries, especially in the US and European Union. Benefit transfer methods have been developed to rely on estimates in one place (e.g., developed countries) to value the environment in other places (e.g., developing countries), but the methodology requires at least certain valuation studies in the latter (Richardson et al. 2015).

Second, it is important to assess the performance of environmental regulations on a regular basis, so as to make improvements and provide insights for future regulatory choices. The assessment should include not only the environmental effects but also the social and economic effects of environmental policies. Such assessments will help promote cost effective policies over command-and-control approaches, especially when the economic costs are included. They also help address the question of whether environmental protection has to come at the cost of economic growth.

Third, regulators themselves should be incentivized to effectively enforce environmental laws and regulations. A number of studies have found that in the PRC, providing incentives to government officials through evaluation and promotion in the bureaucratic systems is effective in incentivizing these officials to enforce environmental regulations (Zheng and Kahn 2013; Zheng et al. 2014; Kahn, Li, and Zhao 2015; Liang and Langbein 2015; Chen, Li, and Lu 2018; Lin, Sun, and Zhao 2019). Specifically, the Chinese government included water quality targets in the annual evaluation of provincial governors, and these studies found that the scheme was effective in reducing water pollution, and the reduction was higher when the governors are younger and thus have more room for being promoted.

Pollution taxes. Taxes in general work better than standards in terms of cost effectiveness, but they might not be able to bring environmental quality improvements as quickly as standards unless they are set at sufficiently high levels and are adequately enforced. The purpose of pollution taxes is to provide price signals about emissions. Therefore, it is important that the tax burden of a firm is tied to its emission level. This has not always been the case in developing countries. For example, the PRC's emission fee system, which is only currently being replaced by an emission tax system, was only partially linked to a firm's actual emissions, as the total amount paid by a firm was negotiated between the firm and the local environmental agency, and was capped by a ceiling (Ma and Ortolano 2000). Further, the tax revenue should be used to reduce other distortionary taxes the firms pay – this aspect is important in making pollution taxes more effective and more politically feasible, but has received insufficient attention in actual policy making.

Tradable emission permits. Despite the increasing adoption of tradable permits, they can require more institutional capacity than taxes to work properly. For example, the initial distribution of permits is often tied to firms' historical emissions, for which data might not be available. Firms might not be experienced in trading permits, and the market has to be sufficiently thick for market makers to come in and facilitate trading. Price fluctuations can add additional uncertainties to firms and can lead to arbitrage opportunities. A lack of information about firms' abatement costs might lead to too many or too few permits being issued, leading to prices that are too high or too low. Price collars can be included in the system, but the levels of the price ceiling and floor can be arbitrary. The main lesson is that permit trading is *not* necessarily the best regulatory approach. It can be dominated by a well-crafted tax system, both in terms of efficiency and implementation. The upside is that developed nations are now much more experienced in operating permit markets, and developing countries can build on their experiences. In the PRC's ongoing effort to establish a nationwide carbon market, it has learned from international experiences, as well as from its own experimentation with several regional markets.

Command-and-control policies. CAC policies such as standards can bring concrete improvements in environmental quality, but often at high costs. The PRC has adopted many authoritarian measures, such as shutting down polluters to meet environmental quality targets. Zhu et al. (2015) find that one particular measure, freezing environmental impact assessment on construction and investment projects (effectively stopping such projects from being approved) in regions that fail to meet regional environmental targets, worked in improving the environmental quality, but it lacked legal foundations and can be costly. The main lesson about CAC policies is that they need to be as flexible as possible. If a quantity policy is needed, i.e., to restrict the total amount of emissions (for example, in the case of highly damaging pollutants such as carcinogens), a tradable permit system works better than standards uniformly imposed on all polluters. If standards have to be used, they should be designed to target larger entities or areas, while leaving room for the smaller entities to choose their responses. For example, instead of restricting emissions from each polluting facility, a "bubble" can be imposed on a larger firm that operates multiple units.

Imperfect enforcement. Despite the large theory literature on environmental regulation with imperfect enforcement (Malik 1990; Livernois and McKenna 1999; Montero 2002; Stranlund, Chavez, and Villena 2009; Stranlund and Moffitt 2014; Oestreich 2017), the empirical literature on imperfect enforcement in developing countries is rather thin. For example, there is no empirically derived guidance on how to balance the probability of inspection and the magnitude of fines imposed on violators. Firms in developing countries, especially small-scale firms, may have limited financial resources and thus

face tighter bankruptcy constraints. For these firms, Earnhart and Segerson (2012) find that increased enforcement can lead to increased pollution, because the penalties faced by firms are limited by the bankruptcy constraint. This has occurred in the PRC, where recent environmental campaigns have forced some firms to close or go out of business. The literature has also studied reasons for which firms might comply with regulations under weak enforcement. Earnhart, Khanna, and Lyon (2014) find that foreign ownership and information disclosure programs can help improve environmental performance. Dasgupta, Hettige, and Wheeler (2000) find that in Mexico, firms' compliance with environmental regulation is significantly affected by environmental management of the firms, implying that compliance is likely to increase if firm managers receive environmental training. Thus, countries with limited enforcement capacities should make an effort to design education and information programs to increase the willingness of firms to comply with regulations.

4.3 Lessons about Informal Regulation

Due partly to the imperfection in formal regulation, there is increasing interest in informal regulation in developing countries. Informal regulation is considered important in filling the gaps before a system of formal regulation is established and enforced, and as complementary to formal regulation in achieving or overachieving the regulatory goals. But does informal regulation work? Is it a substitute for or complement to formal regulation? The literature has found different answers to these questions. For example, Zhang, Mol, and He (2016) argue that the PRC has significantly increased its information disclosure and environmental transparency in response to increasing pollution, but caution that the environmental effects of these measures are still not clear. Below I discuss a number of findings, mostly confirming that informal approaches do work, but they need formal regulation to back them up and should not be used as substitutes for formal regulation.

Informal regulation can bring environmental improvement in developing countries. There is a rich literature finding that informal regulation can work to reduce pollution. For example, Khanna and Liao (2014) review the literature on voluntary and information approaches in both developed and developing nations, including the case of ISO 14001 certification, and find that these informal approaches can be effective in many developing countries. Blackman, Afsah, and Ratunanda (2004) and García, Sterner, and Afsah (2007) show that the Program for Pollution Control Evaluation and Rating (PROPER), a public exposure program in Indonesia similar to the US Toxics Release Inventory, was effective in reducing firm emissions in the short and medium terms, especially among firms with poor compliance records prior to PROPER. Similarly, Wang et al. (2004) find that public rating of the environmental performance of firms in the PRC was effective in raising tier environmental performance. Hettige et al. (1996) use data from the period of 1992–1994 in South and Southeast Asia to show that, despite the lack of strong formal regulation, many firms have adopted clean production practices, driven by new production technologies, community actions, and sometimes public ownership. Kathuria (2007), using water pollution data in the state of Gujarat of India, finds that the press has served as informal regulation and has been effective in some cases in reducing emissions. Powers et al. (2011) demonstrate that India's Green Rating Project, a program that discloses information about firms' environmental performance, reduced the pollution loadings of firms, especially those that are heavy polluters and those located in wealthier communities. The firms' behavior might have been driven by market responses. Dasgupta, Laplante, and Mamingi (2001), using data from Argentina, Chile, Mexico, and the Philippines, find that capital markets react to the announcement of major environmental events related to polluting firms.

There is some evidence that these alternative approaches might work even better than formal regulation if the formal regulation is not strictly enforced. Dasgupta et al. (2001), using data from the PRC, find that back then, inspections of polluting firms were more effective than pollution charges in reducing firms' emissions. Zhang et al. (2008) show that community pressures and the market's reward for improved environmental performance have played increasing roles in reducing pollution in the PRC, relative to formal regulation. In fact, they find evidence that some firms have overcomplied with environmental standards, but only if these other incentives are strong.

Informal regulation should not be a substitute for formal regulation. A caution about voluntary approaches in developing countries is that they should not be considered as replacing formal regulation or their effective enforcement. Voluntary programs can work in developing countries, but they should be complemented by strong regulatory measures that are sufficiently enforced (Blackman 2008). Without formal regulation as backup or as threats, it is difficult for the voluntary programs to succeed by themselves. For example, Blackman et al. (2010) show that, although the Clean Industry Program in Mexico attracted polluting firms to participate, the program did not have long-lasting effects in reducing the participants' emissions after they had graduated from the program (and obtained clean certificates). Talukdar and Meisner (2001) find that well-functioning domestic capital markets are associated with reduced environmental degradation, and Tamazian and Rao (2010) find that financial markets have to be accompanied by complementary institutions (such as institutions in environmental regulation) in order to improve firms' environmental performance.

Partly because there are not always strongly enforced formal regulations to back them up, informal regulation does not always work. Blackman (2010) summarizes 30 studies on alternative (nongovernmental) pollution control policies in developing countries, including community pressure, public disclosure of emissions such as performance evaluation and rating programs (PERPs), and voluntary approaches. He finds that overall the literature does not provide strong evidence that these alternative policies worked in significantly improving environmental quality. Failures occur when firms are not properly incentivized by the market or threats of future regulation. In other words, firms have to be given incentives to reduce emissions, and these alternative policies will need the threat of formal policies or a well-functioning market that fully internalizes public pressure and perceptions. The latter is particularly difficult when causality is hard to establish and when stock markets do not fully incorporate market information.

Informal regulation should complement formal regulation. A natural conclusion from the above discussions is that informal approaches can and should complement formal regulation. With formal regulation in place and enforced, properly designed informal approaches can encourage firms to comply with formal regulation. For example, using data from the paper and pulp industry in British Columbia, Canada, Foulon, Lanoie, and Laplante (2002) show that tightening standards and publishing a list of firms violating the standards worked complementarily to improve firms' environmental performance. Similarly, McGuire (2014) shows that ISO 14001 certification increased firms' compliance with environmental regulations in the PRC. In these cases, firms reduced pollution not for the sake of improving environmental quality *per se*. Instead, information dissemination provided incentives for them to comply with existing environmental regulations.

Firms may or may not benefit from voluntary emission reduction. Despite the widespread evidence that firms do sometimes undertake voluntary activities to reduce their emissions, it is not clear that they gain profit from doing so. For example, Lyon et al. (2013), using data from 2008 to 2011 in the PRC, find that firms that won the Green Company Award did not gain in terms of shareholder values, and some of them, especially those in low-pollution industries and private firms, saw reductions in shareholder values. This observation provides further argument that voluntary actions arise not only from increased public concern about the environment but also from the threat of enforcement and future regulation. Firms will benefit from voluntary actions if the market anticipates payoff from such actions, which comes from both increased consumer awareness and tougher regulation. The environmental attitudes of firms' management can also play a role beyond profit maximization: Nakamura, Takahashi, and Vertinsky (2001) find that for Japanese firms, the incentives to incorporate environmental goals and to obtain ISO 14001 certification arise from both profit maximization and managers' environmental attitudes and values.

Coase bargaining and citizen action. With increasing pollution, there are an increasing number of cases in many developing countries where the victims have taken actions to directly confront the polluters. In the PRC, this type of case has grown in number, resulting in what has been called "regulatory pluralism" (van Rooij, Stern, and Fürst 2016). Pargal and Wheeler (1996) discuss a case of water pollution in Indonesia, and show that, similarly to the predictions of bargaining theory, the outcome depends on the relative bargaining power of the community (victims) and the firms (polluters). Citizen action is a special case of Coase bargaining, which has not been used much in practical environmental regulation. But for developing countries that lack formal regulation, Coase bargaining can help reduce pollution, although most likely at high transaction costs.

5. CONCLUDING REMARKS

Many Asian countries are experiencing severe environmental pollution and are in need of effective environmental regulation. Decades of theoretical and empirical research in environmental economics have generated a number of important and useful lessons for environmental policy making. Some of the lessons are derived from developed-country experiences, but some lessons are particularly relevant for developing countries. In this paper, I have discussed the theoretical underpinnings and empirical regularities of both formal and informal regulation, and summarized a number of useful lessons for practical policy making.

Several lessons are particularly important. First, the foundation for both formal and informal regulation is sufficient capacity for monitoring and enforcement, with adequate information about not only ambient pollution on regional and local scales but emissions at firm level. Effective environmental regulation needs teams of professionals in addition to politicians, and all of them need to be properly incentivized. Second, a realistic criterion in assessing regulations is cost effectiveness, but nonmarket valuation studies on important pollutants can go a long way towards making regulation socially optimal. Third, for many developing countries, tax might outperform tradable permits, but the key challenge is to properly use the tax revenue. There is plenty of room for generating double dividends by recycling the tax revenue to reduce other distortionary taxes. Finally, informal regulation can improve the environmental quality in developing countries, but it should be a complement to rather than a substitute for formal regulation.

I end the paper by highlighting several areas where I believe future work is needed. While the empirical literature includes a large number of papers on developing countries,

especially on the PRC and India, the theoretical literature is extremely sparse on environmental regulation in developing countries. Few of the theory papers adequately account for the institutional and economic peculiarities of developing countries, and the environmental economics profession has a long way to go in coming up with *theories* of "envirodevonomics." Part of the reason is that empirical research on developing countries is restricted and mostly driven by data availability rather than by policy and societal needs. As such, their conclusions, while important, may not provide much-needed empirical regularities that would form the basis for useful theories. Sometimes data are simply not available due to insufficient capacity, but often environmental and health data are guarded and not made public. International environmental negotiations have made headway in this regard, but ultimately it is up to developing country governments to make data policies amenable to relevant empirical research.

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