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Leapfrogging Technology

Masami Kojima

Masami Kojima is a lead energy and environment specialist at the World Bank focusing on joint energy, environment, and transport policy issues, especially fuel quality, vehicle emission control, fuel pricing policy, and the health impact of pollution. She has worked on these issues in Bank programs in Latin America, South Asia, Central Asia, and the Caucasus.

Cost-Effective Solution for Pollution in Developing Countries?

Leapfrogging technology makes sense where technological advances are driven by market demand, as in telecommunications and information technology. But technological advances driven by the need to deal with such externalities as pollution are more complicated, for they do not inherently increase profitability or efficiency. Using air pollution by vehicles as an illustration, this Note examines the issues that need to be considered in deciding whether leapfrogging technology is a cost-effective solution.

The pace of technological advance in the past few decades has opened new possibilities. Consider the technology for controlling emissions from cars, buses, and trucks. Government regulations have driven this technology as much as the technology has driven regulations, resulting in vehicle emission standards in industrial countries that have become increasingly stringent—far more so than those in developing countries. These standards are deemed necessary to adequately protect the public, especially from excess mortality and morbidity caused by air pollution.

But air pollution is much more serious in many developing country cities. Doesn't this argue for imposing standards just as stringent, since the technologies to achieve them are now available? Moreover, since the private sector bears the cost of adopting these technologies, there should be little direct impact on the government budget, removing one of the potential obstacles to implementation.

Danger of considering technology-based regulations in isolation

The argument is appealing. If all else remained the same, imposing stringent standards that require the best available technology would indeed improve air quality, reduce illness, and save lives. But the *if* is a big one—for standards do not operate in isolation.

Standards and policies, consumer behavior, the structure of the auto and fuel markets, and a host of other factors all interact strongly. These interactions in turn determine the cost-effectiveness of policy interventions. What appear to be straightforward technical questions—should new buses be required to run on natural gas? should sulfur levels in fuel be lowered to meet the same ultra-low standards

as those in industrial countries?—turn out to be not only, or even primarily, about technology. Instead, they require policymakers to address wide-ranging issues—from reforming public transport to reducing protective tariffs on fuels.

Moreover, significant differences between industrial and developing countries influence the effectiveness of leapfrogging technology and standards. One of these is the extent to which policymakers have already "picked the low-hanging fruit" in seeking to improve social welfare.

Low-hanging fruit

Government policy should ideally be designed to maximize social welfare at a given cost to society. And since many factors affect social welfare, choices need to be made. That means asking which would increase social welfare more for a given amount spent: reducing emissions from vehicles or, say, expanding access to piped water, basic sanitation, electricity, or primary education.

Industrial countries have already "picked the low-hanging fruit"—that is, taken the measures with higher returns, such as providing water connections, disease control, and public education about hygiene behavior. Only after adopting these higher-return options have industrial countries taken the next step of considering mitigation measures that require the use of emerging (risky) and expensive technology.

Developing countries are still at the first step. Leaving that first step incomplete and leapfrogging to much costlier measures would not make sense. Moreover, in evaluating policy alternatives, what is important is the cost to society, not who pays. Policies whose costs are borne by the private sector should not be seen simply as free to the government. The government may assume much of the burden of implementing "low-hanging fruit" measures, while the private sector may bear most of the initial costs of adopting advanced technology to control vehicular emissions. Ultimately, however, it is society that pays, through consumer spending or taxes. So the principle of first selecting the measures with high benefit-to-cost ratios applies regardless of who bears the initial costs.

Cultural acceptance of costs of compliance

Environmental standards, however lenient, are often not enforced in developing countries. Governments lack funds to set up an effective monitoring and enforcement system, and operators are reluctant to bear the private cost of compliance. As a result, the performance of new technologies for environmental control can be seriously compromised.

For example, vehicles need to be properly maintained to control emissions. But vehicle owners in developing countries rarely perform preventive maintenance, and when their vehicles break down they often use substandard (and thus cheaper) replacement parts. And freight haulers routinely load their trucks far beyond the design limits. This practice may increase private profits in the short run, but it harms social welfare by significantly increasing emissions.

Even when there is monitoring, enforcement often consists of little more than collecting fines or, worse, bribes. All too often, there is little relationship between emission levels (rarely even measured) and the amounts paid by vehicle owners. Moreover, fuel adulteration is rampant, adding to the pollution problem (see Kojima and Bacon 2001).

So the cost-effectiveness of importing the most stringent standards is far from clear. Take the example of the standards requiring ultra-low-sulfur fuels and sulfur-intolerant emission control devices, due to come into force in a few years in industrial countries. The widespread fuel adulteration in developing countries makes it unlikely that importing these standards would be effective. The most common adulterant for diesel is kerosene, which is often taxed little or even subsidized, in part because it is used by the rural poor for lighting. Kerosene is a nearly perfect substitute for diesel, so diverting low-priced kerosene to the automotive diesel sector is a lucrative practice. But adulteration of ultra-low-sulfur diesel with much higher-sulfur kerosene would defeat the purpose of investing hundreds of millions of dollars in refineries for sulfur reduction and rapidly impair sulfur-intolerant emission control devices.

Diesel engines are known for their durability, yet in developing countries they often break down because they are not properly maintained. If older, simpler technologies are not properly maintained, it is even less likely that newer,

more sophisticated technologies will be. That calls into question the durability of advanced emission control devices under these circumstances. Because emission standards are rarely enforced in developing countries, there is little market demand for upgrading and expanding service and repair facilities. As a result, automotive repair garages tend to be underequipped and their mechanics in need of training. The prevalent practice of repairing vehicles when they break down rather than programming preventive maintenance contributes to the lack of qualified technicians using good diagnostic and repair equipment.

That is not to say that all technology-based solutions fail without proper operation and maintenance. A handful do not rely on operators' behavior. One example is the elimination of lead in gasoline. Historically added to gasoline as a cheap octane enhancer, lead has been banned in a growing number of countries because of its serious health effects, especially its effects on the intellectual development of small children. Lead is not naturally found in gasoline. So stopping its addition to gasoline, which can be done at a relatively low cost, instantly stops lead emissions from all gasoline-fueled vehicles, regardless of their age or state of repair. Unfortunately, most technology-based solutions, especially those relying on emerging technologies, do not fall into this category.

Impact of sector policy

In many developing countries the government is heavily involved in the petroleum and transport sectors, usually to the detriment of sector efficiency. The downstream petroleum sector is often characterized by serious distortions, unsustainable subsidies, gross inefficiencies, and a severe shortage of investment—conditions that make achieving significant improvements in fuel quality difficult if not impossible. This is especially true in countries with refineries. Domestic refineries in many developing countries, often owned fully or in part by the government, are protected by import restrictions, quotas, or high tariffs. As fuel specifications tighten worldwide, small or inefficient refineries will find it increasingly difficult to produce fuels that meet the higher standards without even greater protection against competitively priced and cleaner fuels on the international market.

Even in countries with little refining capacity, the government may set prices at every stage in the supply chain and decide who can import what and how much of it. That denies the country the benefit of market signals that can help allocate resources efficiently. Moreover, a competitive market provides a sound basis for attracting new investment without creating contingent liabilities for the government. If the government controls prices or provides significant price subsidies to make fuels cheaply available to consumers, improving fuel quality—which entails cost increases—becomes problematic. Short of raising fuel prices, a highly politicized step, the government will have to further increase subsidies.

Reformulating fuel may not seem too expensive when the costs are computed in terms of cents per liter. But raising the capital to revamp the refineries is a major hurdle, especially for refineries that are uncompetitive and need government protection. Moreover, because automotive diesel serves as an input for such activities as freight and passenger service, raising the price of diesel has an economywide impact (see Gwilliam and others 2001).

Sector policy in passenger service also influences the effectiveness of higher emission standards. Many public transport companies face fare controls and a poorly designed sector structure. Thus when governments impose stringent emission standards on, for example, traditional formal sector buses, they often make the services too costly to operate at existing fares—and too costly for many poor people to use at financially sustainable fares. The usual result is that informal operators enter the market using smaller vehicles, often old and polluting (World Bank 2001). And with numerous operators, each owning a few vehicles, enforcing environmental and safety standards becomes even more difficult.

Without fundamental sector reform, it is difficult to introduce cleaner fuels and advanced emission controls. What do governments need to do? End the protection of inefficiently operated firms such as refineries and transport companies, phase out untargeted subsidies and

allow markets to set prices, create an open and competitive downstream petroleum market, and allow regulated competition in public transport with market entry criteria that include service and environmental performance standards.

Risks associated with novel technology

Commercializing new technology involves several technical and financial risks. First, the performance of the technology is uncertain and can be assessed only after months or, more typically, years of application on a large commercial scale. Unforeseen technical problems are common, especially when the technology is deployed in countries with widely differing income levels.

Second, the costs associated with novel technology fall substantially with greater volume and experience. For example, the refining processes for producing ultra-low-sulfur fuels are continually developing and improving, so significant cost reductions are likely in the coming decade.

Third, rapid development of another technology may end up displacing the one adopted. Consider the battery electric vehicle, once seen as the technology of the future, capable of producing zero emissions. Today many industry analysts no longer consider battery electric vehicles a potentially viable technology. Adopting an emerging technology prematurely can be very costly.

These technical and financial risks are best left to industrial countries, which have the resources to manage them. For developing countries it makes sense to wait, allowing industrial countries to iron out problems with emerging technologies and reduce their costs.

Conclusion

The ineffectiveness of most emission control programs in developing countries has led many policymakers and environmental groups to conclude that technical solutions are the best way to get around the culture of noncompliance. But the same problems that have led to heavy pollution by conventional gasoline- and diesel-fueled vehicles would probably also condemn state-of-the-art control technology to failure. What should developing country governments do? The first step is to ask the right set of questions by placing the problem in a broader policy context. It becomes apparent that technical solutions cannot substitute for sound sector policies. Moreover, sector reform will require liberalization coupled with appropriate regulations.

There is little doubt that developing countries will one day adopt the standards and technologies being developed in industrial countries today. The question is how to phase in appropriate standards cost-effectively. Adopting the latest standards from Europe and North America with little time lag is unlikely to be a sensible solution in most developing countries.

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Telephone: 001 202 458 7281
Fax: 001 202 522 3480
Email: ssmith7@worldbank.org

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