MEANINGFUL TECHNOLOGY TRANSFER FOR CLIMATE DISRUPTION

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Any serious effort to address global climate disruption will require effective technology transfer. Developing countries with growing emissions must somehow make emission reductions without curtailing the economic development needed to alleviate poverty. This must be done in order to permit global abatement on the scale required to avoid dangerous climate disruption. Given the limited financial and technical capabilities of developing countries, this task seems impossible without technology transfer. As policymakers continue to embrace and enhance technology transfer options, it is critical to understand the relationship between technology transfer and policy development in order to formulate more effective policies. Whether through market mechanisms, such as the Clean Development Mechanism (CDM), or direct aid programs, such as the Green Climate Fund, we argue that technology transfer programs must support the elaboration of policies in developing countries by addressing three key issues: additionality, appropriate scale and the promotion of knowledge spillovers. We use these three principles to provide a framework for assessing the potential of both the CDM and direct financial aid to foster meaningful technology transfer, which we define as technology transfer that not only lowers the overall short-run costs of carbon reductions, but also enhances the capacity of these countries to address climate change more thoroughly in the future.

Any serious effort to address global climate disruption will require effective technology transfer. To permit global abatement on the scale required to avoid dangerous climate disruption, developing countries with growing emissions must somehow make emission reductions without curtailing the economic development needed to alleviate poverty. Given the limited financial and technical capabilities of developing countries, this task seems impossible without technology transfer. Until recently, policymakers relied primarily on global carbon markets such as the

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Clean Development Mechanism (CDM) to foster technology transfer. However, such policies have been unable to deliver technology transfer at levels perceived as necessary by the international community. Acknowledging the insufficiency of current efforts at the 2009 UN Climate Change Conference in Copenhagen, negotiators agreed to establish the Copenhagen Green Climate Fund. This fund would provide $100 billion per year by 2020 to support mitigation and adaptation actions in developing countries, a number that dwarfs the $2.7 billion value of all CDM transactions conducted in 2009. These programs might well fund carbon abatement and sequestration projects in developing countries that do not generate credits for the CDM program.

As policymakers continue to embrace and enhance technology transfer options, it is critical to understand the relationship between technology transfer and policy elaboration in developing countries. Whether through market mechanisms, such as the CDM, or direct aid programs, such as the Green Climate Fund, we argue that technology transfer programs must support policy development in developing countries by addressing three key issues: the promotion of knowledge spillovers, additionality and appropriate scale. We use these three principles to provide a framework for assessing the potential of both the CDM and direct financial aid to foster *meaningful* technology transfer. Meaningful technology transfer not only lowers the overall short-run costs of carbon reductions, but also enhances the capacity of these countries to more thoroughly address climate change in the future.

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The Clean Development Mechanism and Direct Aid as Technology Transfer Tools

The CDM authorizes developed countries or their regulated firms to satisfy some of their emission reduction obligations under the Kyoto Protocol by purchasing emission reduction credits. These credits come from project developers implementing technological changes to reduce greenhouse gas emissions in developing countries that have no obligations to reduce emissions. Because carbon emissions are a global public good, the CDM can help developed countries reach their emission targets at a lower total cost by allowing firms in developed countries to substitute cheaper emission reductions in developing countries for more expensive reductions in their home country.

This trading approach to technology transfer contrasts with the model of government aid successfully used in the Montreal Protocol on Substances that Deplete the Ozone Layer. Under the Montreal Protocol, developed country governments contributed significant funding to a Global Environment Facility (GEF) to provide substitutes for ozone-depleting chemicals to developing countries. In return, developing countries agreed to phase out their consumption of ozone-depleting substances a decade after developed countries had done so. The Copenhagen Accord increases the prospects of government aid playing a significant role in technology transfer under the Kyoto Protocol as well.

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Our framework helps evaluate the relative merits of these two approaches, as well as possible forms that they may take. In doing so, it is important to understand the motivations of each approach. The Kyoto Protocol states two purposes for the CDM: help developed countries meet their emission reduction obligations and help developing countries achieve sustainable development.[1] While CDM projects may result in technology transfer, technology transfer is not the explicit goal of the program. Because CDM credits help developed countries meet their emission reduction obligations, credits developed in a trading scheme do not add any direct environmental value to ongoing global efforts to address global climate disruption. Rather, credits become substitutes for developed country abatement. Regulated firms and countries buy credits in order to allow themselves to lessen their own abatement efforts, doing so when purchasing a credit is cheaper than the cost of reducing their own emissions. Thus, emission reduction credits add cost effectiveness, not extra emission reductions, to global efforts to abate greenhouse gases.

Although this process is consistent with the original goals of the CDM (i.e., cost reduction for Annex I countries), it highlights a key environmental advantage of a government aid approach in comparison with the CDM. Government aid is used to purchase reductions in developing countries in addition to reductions conducted by developed countries, rather than purchasing developing country reductions in lieu of developed country reductions. Moreover, technology transfer is implicitly, if not explicitly, a goal of such aid purchases. For example, the Clean Technology Fund administered by the World Bank has received more than $5 billion in pledges from developed country donors to support demonstration, deployment and transfer of low-carbon technologies to developing countries.[2]

Therefore, a key difference between a government aid model and the CDM is that the CDM focuses on enhancing cost effectiveness of developed country efforts, whereas government aid focuses on increasing total reductions by augmenting current abatement efforts.

The CDM's emphasis on enhancing cost effectiveness also has important long-term implications for climate policy. Critics of the CDM often raise concern over the problem of the "low-hanging fruit."[3] Based on the economic principle of diminishing returns, which holds that increased investment produces marginally smaller results as the most profitable options are pursued first, the low-hanging fruit critique argues that CDM projects use up low-cost abatement options in non-Annex I countries, making future emission reductions by these countries more costly. While economists would generally find using these low-cost options first desirable, proponents of the "low-hanging fruit" theory worry that crediting developed countries now for financing exploitation of the cheapest abatement options makes these opportunities unavailable for later use by developing countries. As such, it will be more difficult for developing countries to later reduce emissions on their own making them less willing to agree to binding emission reductions at a later date.

It is possible, however, for technology transfer to counteract the "low-hanging fruit" effect. While it is true that the costs of additional emission reductions at a given time will increase as more projects are completed, the arrival of new technologies provides new opportunities for emission reductions, so that the future costs of reducing emissions can be lower.[4] Moreover, the advancement of climate policies in developed countries leads to innovations that lower abatement costs, even without emission reduction commitments from developing countries. As these technologies become available in developing countries, the cost of emission reductions will fall there too. Technology transfers that lower future marginal abatement costs increase the likelihood that developing countries will agree to future emission constraints. Thus, we argue that it is important that programs encouraging abatement in developing countries not only foster technology transfer, but also drive *meaningful* technology transfer.

Achieving meaningful technology transfer requires paying attention to positive spillovers, additionality concerns and scalability issues. These features enhance the capabilities of developing countries and ensure that emissions are truly reduced. We explore these three sets of issues below and provide some analysis of how they should influence the design of technology transfer programs.

Meaningful Technology Transfer and Positive Spillovers

The question of what constitutes meaningful technology transfer for the purposes of addressing global climate disruption has received relatively little attention in the literature. We define technology transfer and then develop a concept of meaningful transfer based on the creation of positive spillovers below.

What is Technology Transfer?

There is no universally accepted definition of technology transfer. The Intergovernmental Panel on Climate Change (IPCC) defines technology transfer as "a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions."[5] The benefits of the transfer to the recipient developing country, and thus the potential for technology transfer to improve well-being in the recipient country, depend on the type of transfer.

Embodied technology transfer comes through the import of equipment into a country (e.g., flows of equipment). In such cases, the technology is *embodied* in the imported equipment. *Disembodied* technology transfer involves the flow of know-how or experience. Examples include demonstration projects, training local staff and local firms hiring away staff from multinational firms operating in a developing country.

Disembodied technology transfer is important, as it results in knowledge spillovers that provide benefit to society, but not necessarily financial reward to the innovator. Spillovers occur when a new technology enhances the capacity of others to innovate without providing direct compensation to the inventor. These spillovers may take several forms. First, if developing country nationals work on a project and learn something valuable to future climate efforts from their involvement, this can increase capacity. Second, if developing country engineers learn something about abatement technology from the credit-generating installation that enables them to design new abatement technologies, capacity has increased. Thus, a major goal of a program aimed at technology transfer should encourage project designs that generate positive spillovers and create meaningful capacity increases.

While disembodied technology transfers are of great interest to policymakers, they are of concern for private firms, as they enable others to benefit from the firm's technological advances without compensation. For instance, multinational corporations (MNCs) often go to great lengths to keep local workers from leaving the firm to work for a local company in order to prevent knowledge from falling into a competitor's hands. For example, these corporations often pay higher wages than local firms to provide workers with incentives to stay. In some cases, firms may willingly allow disembodied technology transfer in exchange for other opportunities, such as the value of entering a growing market. In other cases, incentives that compensate disembodied technology transfer from the private sector may be needed.

What is Meaningful Technology Transfer?

Not all technology transfer is equal. Simply using a foreign technology may be classified as embodied technology transfer, but such transfers do not necessarily further the goal of increasing developing country capacity to address climate disruption. Meaningful technology transfer should enable developing countries, in due course, to assume appropriate emission reduction obligations on their own. This requires technology transfer to include positive spillover effects that enhance the capacity of developing countries to address climate disruption. This consideration, while absolutely crucial to the climate regime's long-term success, has until recently received little attention in policy literature.

The countries that created the CDM viewed it as a means of both enhancing the cost effectiveness of developed country compliance efforts and transferring technology to developing countries to support sustainable development. Indeed, the Kyoto Protocol specifies that recipient countries "benefit from project activities resulting in certified emission reductions."[6] However, these benefits may take forms other than enhancing emission reduction capacity. For example, discussions of CDM's potential benefits for recipient countries often focus on broader goals such as poverty reduction, increased employment and improvement of local environmental conditions, rather than the benefits of positive knowledge spillovers.[7] Since the CDM does not reduce aggregate emissions (unless it creates positive spillovers), it does not generally offer environmental value and merely serves the purposes of political economy by enhancing the cost effectiveness of developed countries efforts.

Enhancing local emission reduction capacities is best achieved through projects with local involvement. The involvement of local people and firms in the design, manufacturing and installation of projects enhances the opportunities for local benefits by increasing the likelihood of positive spillovers, as embodied technology transfer gets carried out in ways that generate disembodied technology transfer. Developing criteria demanding some level of local involvement may substantially raise transaction costs. However, asking project developers to report on technology transfer as well as local employment and involvement may help promote these goals even if local involvement is limited. Knowledge spillovers depend on a country's absorptive capacity, which describes a country's ability to conduct research in order to understand, implement and adapt technologies arriving in the country. It depends on the technological literacy and skills of the workforce, and is influenced by education, the strength of governing institutions and financial markets.[8] Thus, while it is beyond the scope of programs such as the CDM, international institutions administering direct aid programs must consider not just what technology is transferred, but also how to enhance the capacity of recipient countries to benefit from it.

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The policy of a recipient country can also enhance positive spillovers. CDM projects must be approved by the host country's government. Some countries choose to evaluate the technology transfer potential of projects when considering approval. Because South Korea requires that "environmentally sound technologies and know-how shall be transferred" by CDM projects in South Korea, 88 percent of the emission reductions from CDM projects in the country come from projects that involve technology transfer.[9] Similarly, Chinese guidelines for CDM project approval state that "CDM project activities should promote the transfer of environmentally sound technology to China."[10] China also uses tax and trade policy to encourage technology transfer. Advanced equipment with no domestic substitute is exempt from import tariffs and value added taxation. In other cases, firms can reduce their tax obligations by producing equipment in China.[11] As a result of such initiatives, 75 percent of CDM emission reductions in China come from projects that transfer technology. In contrast, the percentage of reductions coming from projects with technology transfer is lower in countries that do not specifically consider technology transfer when approving CDM projects, such as Brazil or India.[12]

While requiring local involvement can enhance technology transfer, bottom-up policies such as those described above may be more effective in well-developed markets that enjoy substantial leverage relative to smaller markets. Smaller countries may simply fear losing all investment if they demand an effective showing of local benefit. Government aid offers some advantages here. International institutions typically cooperate with host country governments and may more easily insist on local participation than a host country government facing a project developer with no particular commitment to the host country. Domestic aid programs may also insist on some local participation as part of sound project design, which a private project developer might regard as a hindrance.

Companies providing technology will prove reluctant to participate in technology transfer unless they can keep control over valuable intellectual property. In the CDM, the importance of private participation is obvious, as private companies often initiate the relevant transactions. Governments, however, cannot transfer technologies they do not possess, which makes the participation of the private sector in government aid programs also necessary. This has led to recommendations of compulsory licensing to increase access for developing countries to key climate technologies (e.g., UNFCCC 2010).[13] However, many economists raise concerns about such proposals.[14]

The climate regime needs meaningful technology transfer, i.e., technology transfer with significant positive spillovers, in order to make it a catalyst for developing countries' adoption of strong climate policies. Therefore, a clear understanding of how technology transfer could lead to such a desirable outcome should aid in crafting more effective technology transfer policy. Based on our discussion above, we offer two means by which significant positive spillovers act as a catalyst for future policy. First, developing countries would be likely to adopt favorable climate policies if transferred technology lowers the cost of alternatives to fossil fuels, making these alternatives more competitive with traditional technologies. In this respect, it is important to realize that anything that raises the cost of fossil fuels to developing countries, such as an oil shortage, lowers the bar for cost reductions needed to make clean technology attractive. Of course, developing countries will suffer severe consequences from climate disruption, and the technologies that reduce carbon dioxide emissions also usually reduce local air pollution, so that full economic parity between fossil fuels and their alternatives is not essential. Second, normative factors may influence developing countries' willingness to adopt good climate policies. Writers on environmental justice posit that developing countries' willingness to pay some cost to contribute to global climate abatement efforts may be affected by whether they feel that the international regime has treated them fairly on a range of environmental and economic issues.[15] Hence, the technology transfer regime succeeds if—and only if—it radically changes cost differentials and contributes to a favorable political dynamic.

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Additionality

For the CDM to achieve real emission reductions, CDM projects must achieve reductions that would not have occurred without the CDM project taking place. This concept is known as *additionality*. Many CDM projects have not been additional, meaning that they would have happened even if they had generated no carbon credits, in spite of formal legal requirements demanding additionality.[16] When non-additional projects are allowed, Annex I countries increase their emissions without getting any new reductions in return. This means that non-additional credits undermine abatement efforts. Non-additional credits also imply that the CDM is not encouraging meaningful technology transfer. Instead, at best, it is taking credit for technology transfer occurring for other reasons and, at worst, promoting projects for which the recipient country already has domestic capacity.

Without strict additionality criteria, the CDM program cannot generate positive spillovers as purchasers will simply claim credit for positive spillovers from actions that would have occurred even if no credit purchaser existed. Also, without strict additionality criteria, cap-and-trade programs become cheaper not because they are more cost effective—achieving the same level of reduction at lower cost—but because they are less effective. A weak CDM becomes a non-transparent way of weakening, rather than strengthening, environmental programs, thereby weakening their capacity to encourage innovations that might be transferred to developing countries.

Additionality concerns will likely plague some technologies more often than others. Considering the incentives for developing countries to adopt various technologies helps to explain technology adoption choices. Reducing emissions may require firms to take costly actions that provide no direct benefits to themselves. For climate change, examples of such technologies include clean energy sources such as wind and solar, which produce no carbon emissions but cost more than fossil fuel-based energy sources. Other examples include the capture of methane gas from landfills and carbon sequestration from power plants. Climate policies such as the CDM provide incentives to adopt these technologies. In contrast, other technologies may provide firms with private benefits. For example, investors have incentives to invest in energy efficiency, even without environmental policies in place, as reducing energy consumption provides cost savings to users. Fisher-Vanden et al. provide evidence of energy-saving technological change in China.[17] Their study of the energy consumption of 22,000 large and medium-size Chinese enterprises between 1997 and 1999 reveals that 54 percent of the decline can be explained by price changes. Technological change, measured by research and development (R&D) at the firm level, accounts for 17 percent of this change. Overall, since 1980, energy intensity, defined as energy consumption per dollar of GDP, has fallen at a rate of nearly 4 percent per year in China.[18] These studies suggest that, even without CDM credits, firms research, develop and carry out energy efficiency projects. Accordingly, energy efficiency improvements, while desirable, should often flunk an additionality test.

In thinking about additionality, it is also important to understand some fundamentals of the dynamics of environmental progress in developing countries. Developing countries have a long history of adopting environmental standards that induce technology transfer. They just do so later than developed countries.[19] In the past, developed countries' domestic environmental policies have catalyzed the development and refinement of technologies, even those based on typical performance standards. Eventually, developing countries with access to global markets create feasible standards because of their ability to employ technologies developed in response to earlier developed country policies. This implies that even truly additional CDM credits at the time of creation will cease to be additional after a certain period of time.

Until recently, many scholars neglected the role of developing countries' policy when considering technology transfer. This neglect has diminished in recent years, not only because of the ideological shift now underway, but also because of experience with the CDM. As the CDM program became active, policymakers realized that the additionality requirement provided incentives to retard the process of creating developing countries' policy in order to preserve credit eligibility. For instance, if a country required energy efficient lighting, projects replacing incandescent light bulbs with compact fluorescent lighting would not be additional.[20] This is ironic because policymakers have made technology transfer a major goal of the climate regime in order to make it possible for developing countries to adopt pro-climate policies.

As a consequence of this concern, CDM rules were modified in November 2005 so that climate-friendly policies passed after 2001 "need not be taken into account in developing a baseline scenario" to analyze additionality.[21] While this change ensures that CDM's existence does not discourage the creation of beneficial policies in developing countries, it also raises further questions about whether projects approved using this exception are truly additional. Governments adopt pro-climate policies for a variety of reasons. For example, China's decision to make massive investments in energy efficiency and adopt some of the toughest standards for vehicle efficiency in the world reduced development costs and had an impact on local air pollution. These latter policy motivations are a likely explanation for China's efficiency policies. China has not, to our knowledge, sought CDM credits for actions taken to comply with this policy, though the CDM rules now seem to allow this. Even the emission benefits from promoting alternative energy technologies must be considered in concert with motivations such as enhanced energy security when evaluating the additionality of programmatic CDM credits. Ignoring the motivations behind pro-climate policies in developing countries when constructing baseline scenarios has the potential to convert additional progress in developing countries into rationales for more developed country emissions. Under such an approach, energy efficiency or renewable energy policies adopted for reasons having nothing to do with CDM credits does not become part of the baseline one must go beyond in order to earn credits. Instead, projects carried out to merely implement these policies might be considered additional and therefore credit-generating. Countries and parties purchasing these credits, which are earned by carrying out policies that would have been implemented even if the CDM did not exist, can use them to justify evading otherwise applicable emission obligations. Unfortunately though, ferreting out the precise motivations for government policies is a difficult exercise, both in a democracy like India and in a more closed society such as China.

Government aid provides a way around additionality problems and makes it easier to strategically shape technology transfer to support developing country policy progress. In the case of aid, additionality becomes much less of a concern. Government subsidies for non-additional projects do not lead to increased emission reductions in the aid context because no party is using credits to escape applicable requirements. Therefore, funding non-additional projects through government aid simply constitutes a waste of money. Since this waste has no economic value to the funders, they have an incentive to try and avoid it. By contrast, non-additional projects that nonetheless receive CDM approval have value to credit purchasers in the CDM context as long as the governments involved allow use of the credits.

Given this, the reform of the CDM must focus on effectively demanding additionality. This will not be easy. Determining additionality (or non-additionality) involves a comparison between a project and a hypothetical baseline of what the world would be like without the project. This is in principle difficult to accomplish and demands a lot of information. Critics of the CDM, especially brokers and project developers, often decry its high transaction costs.

Concerns about transaction costs often lead to proposals to simply reduce them. In considering such proposals, however, one must consider the value of the benefits that the transaction costs pay for.[22] The CDM generates high transaction costs primarily because of the need to demonstrate and measure real additional emission reductions in an offset context that provides uncertain baselines and other technical problems.

Government aid may generate lower transaction costs because the measurement of reductions does not matter as much in the aid context as it does in a trading program. In an aid program, it is sufficient to identify a strategically valuable technological improvement and fund it without measuring the reductions delivered. In a trading context, however, the amount of additional emission reductions generated determines the amount of reductions given up in the developed countries. Therefore, sufficiently high transaction costs to facilitate adequate evaluation of claims of additional reductions are necessary to ensure program integrity in the CDM context, but not as important in the government aid context.

The CDM has been a political success.

Despite concerns over the CDM's effectiveness, the CDM has been a political success. Developing countries like the investment flows and developed countries like the cost reductions it delivers in exchange for their own domestic efforts. The CDM may have played some modest, positive role in securing historical commitments by developing countries to non-binding carbon intensity targets under the Copenhagen Accord. Domestic concerns about climate disruption and some commitment to good policies that make achievement of such targets feasible—e.g., China's energy efficiency standards—may play a more important role. The political success of the CDM means that the CDM reform must remain on the agenda.

In choosing a balance between direct aid and the CDM, policymakers should recognize that government aid may produce lower transaction costs than the CDM. In reforming the CDM, policymakers should realize that the additionality problem implies a fundamental tension between the goals of minimizing transaction costs so as to maximize nominal technology transfer, and ensuring sufficient environmental integrity to produce meaningful technology transfer.

Scale and the Choice of Mechanisms

A major motivation for the CDM has been the idea that it would generate large capital flows—much larger capital flows than governments would likely deliver.[23] Recent studies, however, recognize that capital flows delivered, or likely to be delivered in the future by the CDM, are too small to meet the needs.[24] Transaction costs are often seen as impeding the maximization of the number of CDM projects. As we have seen, minimizing transaction costs conflicts with the goal of assuring additionality.

In thinking about scale, it is important to recognize that the goal here must be more ambitious than just securing some nice projects or adopting some favorable policies. In light of the technological lock-in problem—when suboptimal technology, once produced, continues to be used even when a seemingly superior technology appears because the costs of switching to the new technology appear prohibitive—the goal must be to heavily influence core developing country decisions about transportation and power.[25] This requires a focus on both technologies that truly alter the nature of energy supply in recipient countries (e.g., focusing on alternative energy over improved energy efficiency) and delivering these technologies at a scale sufficient to lessen the dependence on older, dirtier forms of energy. Without a scale impact, new emissions from new coal-fired power plants and increasing individual vehicle ownership in developing countries will continue to overwhelm any achievements from technology transfer.

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Governments have recognized the need for additional annual flows significantly exceeding $50 billion—perhaps even approaching $100 billion. Developed country governments responded to these studies and those indicating a need for $10 to 20 billion of annual adaptation funding by pledging in the Copenhagen Accord to ramp up public and private donor contributions for mitigation and adaptation efforts to $100 billion by 2013.

It remains to be seen whether governments will deliver their share of these pledges and whether these pledges prove adequate. The worldwide economic recession makes it difficult for developed country governments to meet their ambitious commitments for international aid. Still, the movement seen toward auctioning allowances might make it possible to raise some new funds for this purpose.

In light of the difficulties of achieving adequate scale, the international community will almost surely keep the CDM alive, albeit with some sort of reform, and try to increase government spending. We should keep in mind that each government's expenditure on abatement in developing countries that is conducted outside of the trading context generates developing country reductions in addition to the climate effort by developed countries. In contrast, private finance through the CDM substitutes developing country reductions for developed country effort. It thus does nothing to ameliorate climate disruption unless it generates positive spillovers that lead to future emission reductions. To the extent that the commitment to more funding is driven by a desire for more immediate abatement, governments must provide the funding by ramping up contributions to technology transfer programs. The overall environmental purpose of scaling up technology transfer is to augment, not only cheapen, global abatement of greenhouse gas emissions.

Conclusion

Historically, developing country policy development has been the primary mechanism to secure technology transfer in the environmental arena. Technology transfer programs must focus more directly on supporting policy development, at the risk of otherwise becoming either an impediment to policy development or an irrelevant sideshow. In balancing government aid and the CDM model, and in enhancing design, policymakers must aim for *meaningful* technology transfer. This means that they must aim to stimulate positive spillovers effectively, not just nominally embedded technology transfers, to address additionality and to scale up the program in order to make a real difference in policy development.

NOTES

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