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Chapter V

Technology transfer for climate protection

INTRODUCTION

In previous chapters, we have argued for a big investment push to transform energy production and use, and to diversify economies to make them less vulnerable to climatic shocks. That push is to be spearheaded by public investments, but it will be sustained by drawing private investors into an expanding green economy. It must also be accompanied by the technological advances needed to meet mitigation and adaptation challenges. Those advances will entail diffusing existing low-emissions technologies, scaling up new, commercially ready innovations, and advancing new breakthroughs that expand the technological frontier.

A rapid pace of capital formation is often accompanied by accelerated technological upgrading and learning. However, noting the familiar market failures which tend to slow or halt technological progress, chapter IV suggested that more than rapid growth will be needed: a strong public policy agenda mixing price incentives, regulation and interventionist measures, particularly within industrial policy, will be required to ensure a continuous process of technological learning and upgrading. It also suggested that a developmental state will be needed to promote such an agenda in most developing countries. When the required technologies are not available domestically but have to be imported and adapted to local conditions, that agenda becomes more complicated, in large part because the balance between owners and users of technology is tilted in favour of the former.

Technology flows through several well-known channels, the most important being trade, foreign direct investment (FDI) and cross-border technology licensing. Scientific and technical knowledge also flows internationally through research publications, research collaboration and the movement of skilled personnel. Acceleration of the flows of climate-friendly technology raises many of the same issues and challenges facing any sort of technology. What differentiates those technologies from many others is the urgency and scale of the transfers needed to meet the climate challenge. But there is also an underlying ethical challenge posed by climate-friendly technologies, given that the countries most responsible for

climate change, or at least their corporations, are set to profit through the transfer of technologies to countries that bear little or no responsibility for the problem.

This chapter is concerned with the international transfer and diffusion of technologies for climate change mitigation and adaptation. The focus is primarily on the “North-South” transfer of technologies, which would allow developing countries to undertake cost-effective actions consistent with—and ideally, capable of reinforcing—their wider economic and social development. It identifies some of the main barriers obstructing such transfer and diffusion and proposes measures for overcoming them. Given the scale and urgency of the climate challenge, it suggests paying more attention to the institutional architecture needed to speed the transition to low-emissions development pathways.

TECHNOLOGY TRANSFER: A GLOBAL POLICY CHALLENGE

Technology transfer will be fundamental to effective implementation of the United Nations Framework Convention on Climate Change (UNFCCC) beyond 2012. Indeed, there is longstanding international agreement about its essential contribution. As early as 1972, the United Nations Conference on the Human Environment included explicit language emphasizing the importance of technology transfer for the achievement of environmental and developmental goals. The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, gave a new urgency to the transfer of environmentally sound technologies for climate change mitigation. Subsequent developments have included agreement on a technology transfer framework at the seventh Conference of the Parties to the UNFCCC, in 2001, covering these key themes and areas for action:

- ***Technology needs and needs assessment:*** a set of country-driven activities to identify mitigation and adaptation technology priorities, particularly in developing countries.
- ***Technology information:*** the means, including hardware, software and networking, to facilitate the flow of information between different stakeholders to enhance the development and transfer of environmentally sound technologies.
- ***Enabling environments:*** government actions which are essential to promoting public and private sector technology transfer, such as fair trade policies, removal of technical, legal and administrative barriers, sound economic policy, regulatory frameworks and transparency.

- ***Capacity-building:*** building and enhancing existing scientific and technical skills, capabilities and institutions, particularly in developing countries, to enable them to access, adapt, manage and develop environmentally sound technologies.
- ***Mechanisms for technology transfer:*** support for financial and institutional activities to enhance the coordination of the full range of stakeholders in different countries, to engage them in cooperative efforts through technology cooperation and partnerships, and to facilitate the development of projects and programmes to support such ends.

Later meetings and agreements, including the 2007 Bali Action Plan and the 2010 UNFCCC agreement reached in Cancun to establish a multilateral technology transfer mechanism, have further elaborated the agenda for technology development and transfer to support mitigation and adaptation.

The discussion on promoting technology transfer to tackle the climate challenge has evolved quite separately from discussions of technology transfer to meet development goals. The former has focused on quickly putting technologies to widespread use, in developed or developing countries, through learning and adaptation, and addressing market failures that could get in the way. The development discussion, meanwhile, has recently focused on protecting the international position of the creators and owners of technology by linking intellectual property rights to multilateral trade rules and bilateral negotiations. In this context, the degree of protection of the owners of knowledge is often taken as a measure of countries' commitment to good governance and an indication of the attractiveness of their investment climate to foreign firms, whose presence is seen as the surest guarantor of technology access.

However, neither perspective fully acknowledges the urgency of the technological challenge or links it to a big push onto a new low-emissions growth path. Building momentum towards a low-emissions future will require drawing on a variety of mechanisms at the international level, as well as determined leadership that puts collective security before narrow commercial interest.

INTELLECTUAL PROPERTY RIGHTS

Incentives or obstacles

Intellectual property rights raise the costs of accessing technology; will this become an important barrier to technology transfer? The answer will

depend, among other things, on whether the particular technology has cost-effective substitutes, and on the degree of competition in the industry, which can affect the price of and the terms for licensing. Moreover, the technology covered by an individual patent may provide only a partial capability for exploiting an innovation; total capability may depend on technologies protected by multiple patents or a combination of patented technologies and other forms of knowledge—such as trade secrets and firm-specific know-how, including knowledge embodied in skilled personnel.

There is vigorous debate over whether intellectual property rights, on balance, help or hinder technology transfer. The evidence is inconclusive, and results vary by industry, depending on characteristics such as market dynamism, technological sophistication, importance of RD&D, and ease of imitation and market entry. There is also variation according to level of economic development. In high-income countries, stronger patent rights have been associated with higher levels of productivity, RD&D expenditures, trade flows, FDI and sophistication of the technologies transferred. However, even among these countries, it is unclear whether intellectual property rights are a cause or an effect of these outcomes. Similarly, weak intellectual property rights in the least developed countries tend to be associated with low levels of RD&D and FDI inflows; cause and effect are again difficult to distinguish. Even when technology is transferred to the least developed countries, the principal constraint on its wider use tends to be limited absorption capacity.¹

Given that stronger protection of intellectual property rights raises the costs of obtaining technologies, it has generally been accepted that low-income developing countries should be exempt from strong intellectual property rights-related obligations, and that the strength of those obligations should only rise with levels of development. Yet, because the current international regime is weighted towards owners rather than users of technology, a graduated approach is likely to support large-scale technology transfer only if it is accompanied by complementary measures with respect to financing, RD&D and technical cooperation—which has not been the case in recent years.

The potential trade-off between intellectual property right protection and technology development and transfer is crucial in the context of climate change. As is clear from figure V.1, the distribution of patent ownership of climate-related technologies is heavily skewed in favour of advanced economies. However, a 2007 analysis found mixed evidence of the importance of intellectual property rights in technology transfer.² Based

Figure V.1
Share of patent ownership in the areas of renewable energy and
motor vehicles abatement among selected countries, 2000-2004

Source: Organization for Economic Cooperation and Development, 2007.

on the examination of three sectors (photovoltaics, wind and biofuels), it concluded that, rather than basic technologies, what are usually patented are specific improvements or features. What matters more are other market distortions. Thus in the photovoltaics sector, for example, where there are multiple small players and no clear leader, developing nations such as India and China have been able to enter and compete in the market. Intellectual property rights also do not appear to be barring developing countries from accessing current-generation biofuel technologies, as shown by Brazil, Malaysia, South Africa and Thailand, among others. More significant barriers and distortions are likely to be associated with industries in which a small number of transnational corporations hold substantial market power.

The most significant barriers and distortions are likely to be associated with the market power of a small number of producers, as in the wind sector. Existing industry leaders are hesitant to share cutting-edge technology out of fear of creating new competitors. China and India, which have significant bargaining advantages, have succeeded in building important firms over the past decade. Whether other developing countries will be able to replicate that success is uncertain.

A much harder question is what lies ahead. To the extent that developing countries make a big investment push to establish a low-emissions development pathway, the market for new technologies can be expected to expand rapidly. However, unanticipated obstacles—particularly the emergence of new sectors linked to these technologies—could slow that transition, or necessitate large shifts of resources to already advanced economies through technology payments.

Multilateral actions to accelerate technology transfer among countries can be of several sorts: those that exploit existing flexibilities of the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS), those that require a modification of that Agreement and other disciplines in the framework of the World Trade Organization (WTO), and those that are not necessarily linked to the multilateral trade framework, including initiatives to foster technology-related absorptive capacity and innovation in developing countries through international cooperation.

The flexibility of the TRIPS Agreement

The TRIPS agreement is often viewed as favouring the owners of intellectual property, and constraining potential users in developing countries. It is, however, a complex agreement with several flexible provisions that could be

exploited to promote technology transfer, including the options of limiting patentability and making use of compulsory licensing provisions.

Limiting patentability

Patentability refers to the boundaries that delineate which inventions can be patented. Article 27 of the TRIPS Agreement states that “patents shall be available for any inventions ... in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application”. These relatively loose criteria leave some space for an individual country to formulate its own policy, including limits on patentability that might promote technology transfer and innovation by reducing possible conflict with existing patents.

Based on the stated goals and guiding principles of the TRIPS Agreement, certain technologies could be excluded from patentability, especially those that are deemed necessary to tackle climate change and/or are subject to anti-competitive measures. Examples of such exclusion already exist within the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture. As the ongoing negotiations within the World Intellectual Property Organization (WIPO) of a substantive patent law treaty could eliminate this opportunity, its impact on climate-related technology transfer should be carefully examined before those negotiations are completed.

There are a number of variants on this approach, including worldwide exemption of climate-friendly technologies and products from patenting; exemption from patenting in developing countries only; allowing developing countries to exclude patents for climate-friendly technologies and products, if they so choose; granting of voluntary licences on request, free of royalty; and granting of voluntary licences automatically, with compensation given to the owner of the technology (the latter two being exceptions to patents, not limits to patentability).

These options could be applied on a graduated basis to countries at different levels of development, with more sweeping exemptions for low-income developing countries and voluntary licences for middle- and high-income developing countries. The size of the country could be another criterion for choosing the appropriate option. For a small developing country, regardless of income level, acquiring a licence for climate-related technology may not be profitable unless it is able to use the licence to tap export markets. In that case, the royalty could be reduced or eliminated and/or the exemption from patent rights could be extended to a whole region.

Compulsory licensing

Even when a technology has been patented, articles 30 and 31 of the TRIPS Agreement offer opportunities for allowing use of a patented technology without the consent of the patent holder through compulsory licensing. For example, Article 30 allows unauthorized use of a patented technology by a country when “necessary for the protection of its essential security interests” or “the maintenance of international peace and security”; depending on one’s views of the climate crisis, mitigation and adaptation technologies might qualify under this provision.

Article 31 of the Agreement offers another route to compulsory licensing, providing that a country meets two major criteria. First, reasonable efforts must be made to gain appropriate authorization from the patent holder. This requirement may be waived when the country determines (using its own judgement) that a “national emergency” or “other circumstances of extreme urgency” demand unauthorized use without delay. Discussions leading to the recognition of public health exceptions showed some flexibility in interpreting what qualifies as urgent circumstances, opening the door to potential use of these exceptions in the climate change context.

Second, sales of protected assets must be predominantly in the domestic market for the entity granted the exception. Limiting the technology to the domestic market of one (small or poor) country, however, might prevent the capture of economies of scale which would make the technology cost-effective. Recognizing this fact in the public health realm, the WTO in 2003 approved a temporary waiver of the domestic market requirement for pharmaceuticals in countries with insufficient domestic production.

An amendment to the TRIPS Agreement approved by the General Council of the WTO in 2005 would make this waiver permanent, but years later, it has yet to be ratified by two-thirds of the membership. Such a waiver could conceivably be extended to climate-friendly technologies, but it would certainly meet with strong resistance from owners of technologies in industrialized countries, who could lose potential rents. However, it can be argued that such technologies are not currently reaching developing countries, so the loss of rent would be limited.³

Modifying the TRIPS Agreement

A new “Declaration on TRIPS and climate change” could clarify existing options under the Agreement and offer new incentives for transfer of environmentally sound technologies. In particular, exceptions for least

developed countries and small island developing States could be pursued, given that in these countries, trade and investment flows appear to be relatively unresponsive to protection of intellectual property rights, while the dangers posed by climate change are particularly acute. Such measures should take into account the uncertain and ever-changing nature of the climate change problem and address adaptation as well as mitigation technologies.

Strong pro-competition provisions would also promote technology transfer. TRIPS Article 40 already allows countries to restrict licensing practices that may have an adverse effect on competition. Developed countries could take the lead here in promoting competition by mandating compulsory licensing for climate-related intellectual property rights held domestically. Pro-competition provisions would, however, meet with strong resistance from intellectual property right holders who exert great influence with several members of the WTO.

New licensing guidelines could provide for fixed, moderate fees for licensing environmentally sound, patented technologies. In cases where the patented technology clearly has environmental benefits, the patent holder would bear the burden of proof in demonstrating why compulsory licensing would be unwarranted. A tiered application fee system for intellectual property rights could waive payments for patent holders who authorize transfer of climate-friendly technologies to developing countries.

If the granting of full licences is an unrealistic option, then temporary licences could be granted along the lines established for plant breeders' exemptions and farmers' privileges under the International Treaty on Plant Genetic Resources for Food and Agriculture. For example, intellectual property right holders could provide developing-country users with technologies for a limited period, with the expectation of receiving payment once the technology was "tropicalized"—i.e., adapted to local requirements.

Mechanisms to evaluate progress on technology transfer should be strengthened. Current evaluation procedures offer neither transparency nor a viable enforcement mechanism. In the absence of formal enforcement, "naming and shaming" would at least provide some measure of accountability.

There are, of course, great political difficulties involved in modifying any WTO agreement. Technology transfer measures can often disadvantage patent holders, who have great political influence in developed countries. Moreover, despite the acknowledgment of development goals, the TRIPS Agreement prioritises equal treatment of nations. However, equal treatment of technologies may not be as crucial, as evidenced by the progress on

essential medicines. Global action to address climate change is not a zero-sum game; any country hoping for modification of the TRIPS Agreement in this area will need to stress common interests in advancing the global public good of a stable climate.

Further options for addressing intellectual property rights and innovation incentives

The institutional role of the WTO in the area of climate change is just beginning to be explored. However, the potential clash between trade rules and climate concerns raises serious issues, particularly for developing countries. Other proposals for facilitating technology access and diffusion, which may or may not be consistent with a WTO framework, include:

Open-source information access and increased sharing of public R&D results

Limited access to information on available technologies is a constraint on technology transfer and adoption. One proposed solution, discussed as far back as 1992, is to establish an information access agreement or an information clearing house of climate-friendly technologies. Some efforts have been made by the UNFCCC on technology transfer and technology needs assessments, but they need to be expanded and better integrated with wider development initiatives.

The Multilateral System of Access and Benefit-Sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture could also be a model for an agreement on access to climate-friendly technologies. Along these lines, a 2006 proposal called for a formal agreement on access to basic science and technology “to ensure widespread access to essential scientific results and to enhance the transfer of basic technological information to the developing world at reasonable cost”.⁴ As a WTO agreement, this instrument could take advantage of the dispute settlement mechanisms and other institutional structures.

One difficulty with such an agreement would be the challenge of drawing an acceptable line between “basic” and “applied” research. The definition of what is “basic” (and therefore eligible for low-cost transfer) could be construed more broadly in the context of global public goods, so as to favour climate-friendly technologies. In borderline cases, guidelines concerning which research results were confidential and which could be made public would need to be established.

Dedicated funding mechanisms

National governments can subsidize technology development and transfer, through direct subsidies, tax breaks and other fiscal incentives. They can direct the focus of private firms towards particular sectors, such as those encompassing climate change-related technologies, by reducing the risk level of RD&D projects. However, the financial impact of individual governments is limited. Moreover, such expenditures can be exploited by “free riders” on the global level.

A coordinated international funding mechanism would help solve the free-rider problem. Possibilities in this regard include a trust fund encouraging RD&D directly in developing countries, a patent acquisition fund established to buy intellectual property rights from patent holders, and a fund that covers the difference in cost between environmentally sound technologies and business-as-usual technology for developing-country firms. An example of the latter type of mechanism is the Multilateral Fund for the Implementation of the Montreal Protocol, which helped finance the phase-out of ozone-depleting substances.⁵

Another alternative which could circumvent intellectual property rights problems is a technology prize system. Within such a system, the performance characteristics of a desired technology would be defined, a contest would be announced for its development, and a prize would be awarded to the successful innovator in exchange for the intellectual property rights. Prizes help to reduce wasteful spending on marketing and to lower incentives for anti-competitive behaviour; they work best with a specific, clearly defined objective, such as creating a vaccine for a specific disease.

Technology development and transfer mechanisms

An international technology transfer mechanism could be established under the auspices of the Conference of the Parties to the UNFCCC. Supported by a secretariat and expert panels, it could examine the technology challenge in developing countries and, where appropriate, provide technical assistance on the range of technology options available for mitigating and adapting to climate change. This model has been successfully employed within the Montreal Protocol and could be applied to the climate change context.

At regional and national levels, centres dedicated to low-emissions technology innovation and diffusion could be created and linked to and through the international mechanism. They would have an important role to play in making technologies accessible and affordable in developing

countries. At least in the initial stages, these centres are likely to be publicly funded, though the precise mix of donor, public and private funding would vary across countries and over time. The appropriate mixture of basic research, field trials, business incubator services, venture capital funding, technical advice and support, and policy and market analysis will depend on local conditions and challenges.

TECHNOLOGY TRANSFER THROUGH INVESTMENT

Accessing clean technologies through foreign direct investment

Many descriptions of foreign direct investment (FDI) emphasize that it is the exploitation of firm-specific advantages, including intellectual property and leading technologies, that allows large corporations to undertake risky and costly activities outside their immediate domestic and regional locations. Hosting foreign firms is seen as a way for developing countries to close the technological gap with more advanced countries. To attract those firms, developing countries have liberalized rules on FDI and trade and, in some cases, created export processing zones, with the expectation that this would help break both technological and foreign-exchange constraints on growth. The results have often been disappointing, particularly in cases where FDI has been a substitute for local domestic capacity-building efforts.

While technology may be physically transferred from the home to the host country through FDI, this does not determine what sort of linkages the transfer creates with the rest of the host economy. How large are the technology spillovers, and do they, as Albert Hirschman asked in 1971, act as “a spur to the expansion of missing local inputs” or “harm the quality of local factors of production”?⁶ Answering these questions in greater detail would require a long detour, but two broad findings stand out in the research literature. First, FDI tends to be a lagging variable in the growth process; it is attracted by various factors such as market size, presence of suppliers, human capital, etc., which are the result of a successful development push. That is, FDI is more reliably a follower than a leader of the development process. Second, even when FDI does materialize, active policies are needed to ensure that there are valuable spillovers into the local economy.⁷

Those spillovers can occur in a number of ways: through the movement of skilled personnel between a multinational subsidiary or joint venture and other firms; through technology imitation by competitors; and through technology sharing with suppliers, customers or business partners.

Strong intellectual property right protection is not necessary for extensive foreign investment to occur, as China clearly demonstrates. The country's large market and rapid growth have compelled foreign companies to invest, even at the risk of losing control of proprietary technologies. Countries with "weak" intellectual property right regimes, such as the Republic of Korea, Taiwan Province of China and Brazil in the pre-TRIPS Agreement era have been major technology borrowers, reaping substantial benefits from spillovers from multinational corporations.

Recent research on FDI as a vehicle for technology transfer has pointed to conditions that influence the extent of knowledge spillovers. One study used industry panel data from Indonesia to examine knowledge spillovers between subsidiaries of Japanese multinational corporations and Indonesian firms, and concluded that spillovers were significant only when the Japanese subsidiaries had invested in RD&D themselves.⁸ A subsequent study found a significant positive relationship in Indonesia between the training investments of local firms and the extent of knowledge spillovers from foreign ones.⁹ All of these findings lead to the conclusion that technology or knowledge transfer through FDI is not automatic, but depends on complementary investments by both foreign and local firms.

There has been little research undertaken to date on the role of FDI spillovers in supporting a transformative low-emissions growth path. Kelly Sims Gallagher's 2006 study of China's automotive industry suggests that hosting FDI is, by itself, no guarantee of technology transfer.¹⁰ China's transportation sector has grown particularly rapidly since the early 1980s, thanks in part to joint ventures with foreign automobile companies producing largely for the growing domestic market. This growth has, in turn, contributed to rapid growth in oil imports. Until 2000, the sector was subject to few regulations and standards on emissions; since then, stricter regulations have been introduced in an effort to force foreign firms to transfer cleaner technologies. However, while these firms have introduced more modern pollution control technologies, they have been reluctant to introduce cutting-edge technology, and the overall impact of their efforts has been dwarfed by the scale effect of rising car ownership. The study concludes that market incentives are, by themselves, unlikely to help China jump to the next stage in terms of cleaner vehicles, such as fuel-cell vehicles, given prohibitive prices and the control exerted over intellectual property by foreign firms. Rather, the government will need to consider a more comprehensive and integrated policy approach, one that seeks to bolster local learning in the automotive sector through support for RD&D and engineering training, and efforts to foster demand for cleaner automobiles in response to higher prices and tighter regulations.

CDM and technology transfer

The Clean Development Mechanism (CDM) was established under the Kyoto Protocol to help developed countries meet their emission targets, by encouraging firms in the private sector to contribute to emission reduction efforts through investments in developing countries. Many of these projects involve multinational corporations from advanced countries. It was expected that such private sector transfers would assist in the transfer of environmentally sound technologies to developing countries.

A few studies have tried to determine to what extent technology transfer is actually occurring through the CDM process. A review by the UNFCCC found that of the 4,984 projects that were in the CDM pipeline as of mid-2010 (including 2,389 that had been registered by the CDM Executive Board), at least 30 per cent—accounting for 48 per cent of estimated emission reductions—involved technology transfer. The rates of technology transfer vary considerably by project type, the review found: only 13 per cent of hydro projects, for example, but 34 per cent of biomass energy and wind projects, 82 per cent of landfill gas projects, and all N₂O projects. Four countries—Germany, the United States, Japan and Denmark—produced 51 per cent of the transferred technology, and 84 per cent of the total came from developed countries. Overall, larger projects were likelier to involve transfer, while only 25 per cent of small-scale projects and 27 per cent of unilateral projects did.¹¹

So far, the operation of the CDM has been on too limited a scale, and too heavily concentrated in a few developing countries, to allow it to initiate and sustain the kind of big push towards cleaner technologies recommended in this book. Moves towards the creation of a simplified CDM, including sectoral or technological benchmarks, might make it more effective in raising technological standards in the longer run. However, this is likely to take time.

TRADE AND CLIMATE-RELATED TECHNOLOGY TRANSFER

Climate policy discussions have led to a revival of North-South trade and environment debates on how to distinguish between legitimate environmental and health protection measures, as allowed in the WTO, and disguised trade protectionism measures. Despite the establishment of a WTO Committee on Trade and Environment in 1994 to address contentious trade and environment issues, such as how to speed up the

transfer of environmentally sound technologies while remaining WTO-compliant, not much progress has been made. Given the absence of prior agreements, more trade disputes are to be expected on measures to account for the carbon-intensity of traded goods and on subsidies to encourage the development of lower-carbon energy sources.

Both the UNFCCC and the WTO recognize that advanced and developing countries are not in equal positions—the UNFCCC through its principle of common and differentiated responsibilities, and the WTO through the principle of special and differentiated treatment for developing countries. In practice, this means that, for instance, under the Kyoto Protocol, developing countries did not have binding greenhouse gas reduction commitments, although they were required to collect data and undertake mitigation and adaptation measures. The level and extent of those measures, however, depended on promised financial, technological and capacity-building support from developed countries.

Along with intellectual property policy changes, some have proposed faster liberalization of trade in climate-related environmental goods and services. In particular, there have been proposals to revisit the Agreements on Subsidies and Countervailing Measures, contained in the 1994 Marrakesh Agreement, to allow subsidies that foster investments in low-emissions technologies.

Trade is important because imported capital goods and services provide an additional channel to access environmental technologies and know-how generated in developed countries. Nonetheless, trade liberalization on its own is not sufficient. Indeed, despite unprecedented market liberalization under the WTO in recent years, and existing technology transfer commitments within the UNFCCC, evidence of technology transfer is slim. Liberalization of trade in environmental goods and services has been slowed by a number of factors, including inaction on the WTO's Doha Development Agenda, the lack of agreement about what constitutes environmental goods and services, and the different views held by the North and the South regarding which tariffs should be lowered more quickly.

Liberalization of trade in climate-related environmental goods and services

In general, developing countries rely much more on tariffs to generate revenues than do developed countries, which have the institutions in place to collect income and sales, or value-added, taxes. The same was true of

today's high-income countries at an earlier stage of development: tariffs accounted for more than half of the United States Government revenue in all but 10 of the 122 years from 1789 through 1910.¹² For developing countries that are still in the tariff-dependent stage, significant reduction of tariffs means lower revenues for investment in social and infrastructure development.

With respect to liberalization of environmental goods and services, developing and developed countries have different goals. The former want access to adaptation technologies, while also seeking to protect their nascent environmental goods and services industries so they can eventually compete in world markets. In contrast, developed countries currently have comparative advantages in capital- and technology-intensive environmental goods and services, and propose early liberalization of those goods.

Another obstacle to agreeing on a list of eligible environmental goods and services or climate-related technologies is the lack of specificity in the customs data that tracks traded goods and services. The World Customs Organization Harmonized Commodity Description and Coding System (HS) has been harmonized to only a six-digit level. At that level, customs data are still highly aggregated, with a single category, for example, for "pumps for liquid", including those used in manufacturing wind turbines but also those for other industrial processes. Lifting tariffs on the entire category in order to promote wind power would mean extensive lost revenues and would expose local enterprises, often small and medium-sized, to international competition.

Thus, developing countries fear that the negotiations on environmental goods and services are yet another attempt at prying open their markets. Meanwhile, they observe that developed countries have been slow to meet their obligations regarding the technology transfer, capacity-building and financial assistance required to allow developing countries to acquire climate-related technologies.

Developing countries would have more flexibility if WTO commitments did not require them to lower or eliminate tariffs on all "environmental goods". They would then have the option to develop their own industries and products while maintaining appropriate tariffs, or to lower tariffs on certain environment-related products. This is important because, increasingly, WTO tariffs reductions are bound; in other words, once lowered, they cannot be raised again. Without proper safeguards, the accelerated liberalization of tariffs on environmental goods and services would reduce the policy options available to developing countries for promoting local production along their low-emissions development pathway.

Another definitional issue concerns traditional environmental goods and services such as water treatment, waste collection, and pollution control technologies, versus environmentally preferable products. Proposed lists of environmental goods and services have typically emphasized capital- and technology-intensive pollution control products. Environmentally preferable products, instead of providing an end-of-pipe solution to pollution, reduce pollution during the production process or during the use phase of a product. Well-known examples are organic foods and coffee, and goods which are more energy-efficient in use, such as hybrid cars. The debate over environmentally preferable products in the WTO is at heart a debate about whether (and how) the WTO can distinguish between otherwise similar products based on their processes or production methods.

The most-favoured-nation and national treatment principles now incorporated in the WTO prevent discrimination among “like products” originating from different trading partners, as well as between a country’s own and foreign products. Developing countries, fearing that developed nations could use processes or production methods as the basis for non-tariff barriers (by imposing high process-related environmental standards hard to achieve by developing countries), have always taken the position that if the end products have the same physical characteristics, then they are “like products” regardless of how they were produced. However, recent dispute panel findings seem to indicate that, as long as measures to protect the environment do not discriminate between domestic and international producers, or among international producers, they are WTO-compliant under a provision of the General Agreement on Tariffs and Trade (GATT) which allows exceptions to WTO trade rules to protect human, animal or plant life or health.

Embodied carbon

As developed countries adopt climate policies, their energy- and carbon-intensive industries fear having to compete with producers abroad who do not face higher energy prices. Developed-country governments may also fear so-called carbon leakage—the relocation of such industries to non-regulated countries, with associated economic costs and no environmental benefit. A number of developed countries have proposed border adjustments that would “correct” for the differential in carbon emitted in the production of imported goods. If all developed countries join a regime of binding quantitative emission targets, then these measures would be directed largely

at developing countries. The intention is to encourage them to become part of a regime of binding targets as well.

Legal experts differ on the details, but many doubt that most border carbon adjustments could be compliant with current WTO rules. Developing countries will eventually have to make significant cuts in their emissions anyway, but for reasons outlined in earlier chapters, they cannot be expected to do so on the same terms or in the same time frame as developed countries, or without financial and technological support. Using stronger measures to try to force developing countries to take on binding commitments is likely only to erode trust between North and South, especially as developed countries have yet to deliver substantial financial and technological support for emission reduction.

Border adjustments are also unlikely to achieve their goal. Only a few energy-intensive sectors (steel, aluminium, paper, chemicals and cement) would be affected, and these are only responsible for a small proportion of economic activity in the developed world. Also, if the border measures cover only basic materials such as aluminium, they hurt the domestic producers that use this input in their processes. If, instead, border adjustments cover manufactured goods such as aluminium-frame bicycles, it would be virtually impossible to calculate the appropriate adjustments on the vast number of products involved in international trade.¹³

Nonetheless, environmental standards can be effective industrial policy instruments for accelerating technological transformation. At present, technical standards are often determined by governments (unilaterally or through agreements among a reduced number of countries) or set by private companies. Wider participation of all parties in the setting of these standards, especially developing countries, should guarantee that environmental standards (including through green labels and ecological footprint certificates) do not become a means of promoting unfair trade protectionism. The Montreal Protocol process, which identified the substances that would be banned and the pace of their elimination, may again serve as an example: the Montreal Protocol provided financial support for adjustment to the agreed standards. A similar, but much more ambitious mechanism to compensate countries economically disadvantaged by the standard-setting of other countries could be devised as part of global financing mechanisms for sustainable development. In addition, a global technology policy mechanism, such as the Technology Executive Committee established by UNFCCC in Cancún (Mexico) in December 2010, could serve as an appellate body where parties adversely affected by

such standard-setting could seek a ruling from an expert panel on whether the standards were supported by scientific and practical consideration, as opposed to being protectionist actions.¹⁴

Low-emissions energy subsidies

The energy sector produces two thirds of the greenhouse gas emissions that cause climate change; along with taxing or capping CO₂ emissions from fossil fuels, many policymakers support subsidies to alternative energy sources. Such subsidies may also raise questions of WTO compliance; however, this issue may be easier to resolve than others because there is a precedent. There was an exception for environmental subsidies under the Agreement on Subsidies and Countervailing Measures; it lapsed in 1999 but could be revived to allow climate-related subsidies that do not injure competitors in other countries.

If the exception for these subsidies could be renewed, both developed and developing countries would be allowed to subsidize general research on climate mitigation and adaptation, without fear of trade sanctions. It is unclear whether free allocation of emissions allowances in carbon trading systems—as proposed in the United States Congress in recent years—would be considered subsidies under the Agreement on Subsidies and Countervailing Measures; a 2009 review found no jurisprudence on this point.¹⁵ It is worth noting that under that Agreement, a country's failure to take action on climate change would not constitute "a subsidy".

The multilateral investment agreement, the Agreement on Trade-related Investment Measures, raises few concerns in this realm, but the 2,500 bilateral investment agreements and the bilateral investment chapters in regional trade agreements contain strong measures—in some cases, perhaps stronger than intended. In the North American Free Trade Agreement (NAFTA), expropriation was so broadly defined and led to so many arbitrations that the United States, Canada and Mexico agreed to clarify and limit the definition of which investors could claim it. These arbitrations have, in some cases, had a chilling effect on countries considering stronger regulations. The fear is that investors could claim that the new regulations constituted unfair and inequitable treatment. Clarification on which climate-related investments could constitute indirect expropriation would give countries the freedom to adopt appropriate regulations without the fear of having to pay excessive compensation to foreign companies.

INTERNATIONAL MEASURES FOR CAPACITY BUILDING

Technology absorption requires investment in both physical and human capital; the faster the pace of capital formation, the greater the potential rate of technological change. In this process, promoting local technological learning and capacities will be critical. Technology needs will differ from region to region, but in all cases, active government policy will be a component of successful outcomes (see chap. IV). Moreover, the global nature and urgency of the climate challenge imply that the rapid dissemination of appropriate technological options will require international collaboration.

This is particularly true in the area of RD&D, where developing countries lag significantly and risk falling further behind as new technologies emerge. Examples of technologies that will be critical to a new development pathway include carbon capture and sequestration (CCS), low-emissions biofuels, and breakthroughs in renewable energy such as photovoltaic panels. Moreover, developing countries also need access to best practices with respect to adaptation technologies, in the areas of agriculture, disaster management and urban planning. These technologies are often closely interrelated and can also address food and energy security. Developments in all these areas are best addressed through a structured global programme and funding, to develop greater coordination among the myriad research institutions working to meet these challenges, and to ensure the widest dissemination of the results (box V.1). Transparent and readily accessible research is all the more important because regulatory and legal frameworks, such as standard-setting, are likely to emerge on the basis of these results.

Particularly with respect to cutting-edge technologies, well-educated engineers and managers are essential. Enhanced education and training programmes are needed in the areas of technical, administrative, financial, regulatory and legal skills. Along with improving domestic educational programmes, developing countries can guard against a “brain drain” by offering incentives such as wage flexibility, repatriation grants, and support for technology start-ups. Developed countries, for their part, should subsidize offshore training, conference attendance and, in some cases, temporary employment for graduates from developing countries. Grant proposals for research on environmentally sound technologies involving developing-country teams could also receive special consideration. Capacity-building might also be pursued through the cooperation agreements that increasingly accompany regional trade agreements among OECD countries. These would help developing countries conduct an assessment of the obstacles to their low-emissions energy development. Aid-for-trade programmes should also be tapped in this regard.

Box V.1: Intellectual property rights and publicly funded technologies

The issue of publicly owned technology transfer was addressed at the United Nations Conference on Environmental Development, held in Rio de Janeiro in 1992. The agenda included a statement that governments and international organizations should promote the “formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain.” Implementation of this provision has been very weak.

Developed-country governments sponsor a range of research and development (R&D) activities geared towards climate technologies. For example, in 2010, European governments spent \$1.1 billion on R&D in renewable energy, slightly more than the private sector; the United States Government spent \$1.0 billion, twice as much as corporations. “Green stimulus” packages in those countries as well as in Japan, South Korea and Australia have given a significant boost to renewables R&D.

A 2005 survey of government-sponsored R&D in the United States, Canada, the United Kingdom, the Republic of Korea and other countries that are members of the Organization for Economic Cooperation and Development (OECD) found that it is a common practice for governments to grant ownership of intellectual property rights (patents, copyrights, trademarks, etc.) to the recipient research institutions. In the United States, for example, government-sponsored research usually ends up being patented.

Given the role that governments play as the main driver of R&D for climate technologies, it will be necessary to explore possibilities for the transfer of publicly funded climate technologies to developing countries. In OECD countries, where ownership of most of the technology needed for mitigation and abatement is held, governments are in a strategic position to influence technology flows through their influence on private sector entities or public institutes which receive funding for R&D.

Sources: Sathaye et al., 2005, United Nations Environment Programme and Bloomberg New Energy Finance, 2011.

What is clearly required is a massive international effort. Table V.1 presents various mechanisms to promote technology development and transfer. Three closely related initiatives could plant the seeds of greater international collaboration in this area:

- **A *multilateral technology fund*** to support an international programme on the diffusion of climate technology and to strengthen and coordinate regional and national RD&D efforts in developing countries. Such a fund could be housed in the secretariat of the UNFCCC and draw on the existing network of scholars and scientists within the Intergovernmental Panel on Climate Change (IPCC) in the design of its programmes. It could draw on the experience with the Global Environment Facility (GEF) (see box V.2). A comprehensive programme would need to focus on the full range of technological challenges throughout the basic science, applied research, demonstration, deployment and commercialization stages of

Table V.1 Innovative mechanisms to promote technology development and transfer		
<i>Mechanism</i>	<i>Rationale</i>	<i>Issues to consider</i>
Publicly supported centres for technology development and transfer	The Green Revolution model: makes technologies available to developing countries without intellectual property rights protection	Suitable for mitigation, or only for adaptation technologies?
Technology funding mechanism to enable participation of developing countries in international R&D projects	Resultant intellectual property rights could be shared; patent buyouts could make privately owned technologies available to developing countries	Is there sufficient incentive for participation by developed-country private sector technology leaders?
Patent pools to streamline licensing of inventions needed to exploit a given technology	Developing-country licencees will not have to deal with multiple patent holders	What are the incentives to patent holders? Would government regulation be needed?
Global R&D alliance for research on key adaptation technologies	Model of research on neglected tropical diseases	Is such an approach suited to mitigation technologies?
Global clean technology venture capital fund	Fund located with a multilateral financing institution which will also have the rights to intellectual property	Will new technology ventures be commercially viable if they do not own intellectual property?
Eco-Patent Commons for environmentally sustainable technologies	Private sector initiative to make certain environmentally sound technologies available royalty-free on a "give-one, take-one" model	Voluntary, private incentives appear weak. What about those companies without a patent to contribute?
Blue Skies proposal of European Patent Office: differentiated patent system with licensing of rights to climate change technologies	Complex new technologies based on cumulative innovation processes need to be treated differently from, for example, pharmaceuticals	Appears to address concerns similar to those addressed by the patent pools proposal: more specifics needed on implications for technology access
More favourable tax treatment in developed countries for R&D performed in developing countries	More proactive, technology-push approach by developed-country governments	May face domestic political constraints
Technology prizes	Reward innovation without awarding intellectual property rights to innovators	Requires a well-specified research objective
Source: United Nations Department of Economic and Social Affairs, 2008.		

Box V.2: The Global Environment Facility

Technology transfer will play a critical role in the global response to climate change, and promoting it is one of the commitments embodied in the United Nations Framework Convention on Climate Change (UNFCCC). Parties to the Convention agreed to provide funding to support these goals, and the Global Environment Facility (GEF), an independent entity that already served as the financial mechanism for other environmental programmes, was chosen to administer the new funds.

Established in 1991, the GEF is the world's largest funder of environmental projects. As of early 2011, it had allocated \$9.2 billion—supplemented by more than \$40 billion in co-financing. Climate change projects are among the biggest funding areas, with \$2.8 billion invested from 1991 to 2009 (through UNFCCC and other funds). Most financing is in the form of grants to developing countries and countries with economies in transition. Through its Small Grants Programme, which typically awards \$20,000 to \$35,000 at a time, the GEF has also made more than 13,000 grants, worth more than \$304 million, directly to non-governmental and community organizations. Below are some examples of technologies supported by the GEF.

Energy-efficient lighting and appliances

The GEF has built a portfolio promoting energy-efficient appliances and technologies in developing countries. Supported interventions typically focus on instituting energy-efficiency standards and labels, consumer education, and testing and certification of appliances. In countries where there is substantial manufacturing capacity, the GEF has also supported enterprises in developing new energy-efficient appliance models and in acquiring technical information and knowledge from more advanced countries. In Tunisia, for example, a GEF project helped 10 out of 12 local appliance manufacturers develop more energy-efficient models.

Industrial energy-efficiency technologies

The GEF has funded industrial projects in several countries to promote technology upgrading and the adoption and diffusion of energy-efficient technologies. Some projects focus on the development of market mechanisms such as energy service companies, the creation of dedicated financing instruments, and technical assistance to stimulate investments in new technologies. Others are designed to identify one or more subsectors where specific technologies can be promoted. The range of industries includes construction materials (brick, cement and glass), steel, coke-making, foundry, paper, ceramics, textiles, food and beverage, tea, rubber and wood. A number of projects also promote energy-efficient equipment such as boilers, motors and pumps, as well as cogeneration in the industrial sector. In some projects, the GEF has promoted South-South technology transfer; for example, energy-efficient brick kiln technology was brought from China to Bangladesh.

High-efficiency boilers

The China Efficient Industrial Boilers project received a \$32.8 million grant from the GEF to upgrade existing boiler models, adopt new high-efficiency boiler models by introducing modern manufacturing techniques and boiler designs, and provide technical assistance and training for boiler producers and consumers. Completed in 2004, the project successfully worked with nine boiler manufacturers and nine boiler auxiliary equipment makers. With GEF support, the manufacturers in China acquired

Box V.2 (cont'd)

advanced efficient boiler technologies, built prototypes, and began commercial production. Through technical assistance, the project also led to the revision and formulation of national and sector standards, while strengthening the technical capacity of China's boiler sector.

Solar water heaters

Solar water heater technology may seem simple, but it is not. High-quality fittings, solar collectors and installation are required for satisfactory operation. Accordingly, inexpensive materials, poor workmanship and shoddy installation have often resulted in non-functional units and abandonment of installations. GEF experience has shown that knowledgeable staff and the observance of high standards are critical to the successful dissemination of this technology. In Morocco, for example, a GEF project supported upgrades to older solar installations, training for technicians to ensure higher-quality new installations, and subsidies that revived the market.

Waste to energy

Several projects that support the use of methane from municipal waste have qualified for GEF funding as both renewable energy projects and short-term response measures, because of their cost-effectiveness. The India biomethanation project, for example, was designed to exploit India's endogenous capacity to adapt and replicate biogas technology for industrial wastes. The GEF played a role in helping increase the uptake of such technologies, which have gone on to become highly profitable when implemented under the Clean Development Mechanism.

Concentrating solar power

The GEF, together with India, Mexico, Morocco and Egypt, developed a portfolio of four concentrating solar power demonstration plants. The projects built solar fields, typically with 30 MW capacity, as part of hybrid gas-turbine plants. Successful hybridization of the gas-turbine and solar power plants would enable the projects to dispatch power at will, thereby making them more economically attractive.

Source: Global Environment Facility, 2011, and other GEF materials.

cleaner technologies. Critical technologies such as carbon capture and sequestration and the next generation of biofuels, in which developing countries have a particular interest, would have to be high up in the agenda. Given the public nature of RD&D, it would be essential to ensure dedicated and predictable financing for such a fund, using the kinds of instruments discussed in chap. VI. Such a fund could act as a focal point for the coordination of ongoing research in climate technologies at the international and national levels and among public, private and non-profit organizations, while ensuring open access to all available research in line with the urgency of the challenge.

- ***A human skills transfer programme.*** A scaled-up human capacity development effort could consist of a temporary (perhaps only a

virtual) movement of skilled unemployed/underemployed workers from developed countries (engineers, technicians, primary education teachers, experts in sustainable agriculture, and qualified blue- and white-collar workers) into developing countries to provide technical and vocational training. This could involve “reverse outsourcing”, that is, programmes utilizing the Internet and other communications technologies to provide long-distance training services in critical areas for developing countries. During a recession, many highly skilled technicians, teachers and professionals are laid off. Even if only a small fraction of them participated in a technology transfer corps for six months to two years, a significant transfer of skills and know-how could be achieved. This would be a win-win solution for developing countries requiring more help and for cash-constrained developed countries obliged to pay unemployment insurance.

- ***A public technology pool.*** The results of fully funded public research on climate technologies should not be the basis of private patents: they should be made available at low or no cost to all countries. A technical secretariat would be needed to monitor, collect and disseminate such research, to act as a clearinghouse for existing publicly funded technologies, and to actively promote access to those technologies, particularly for developing countries. An important step in this direction was made through the UNFCCC agreement, reached in Cancún in December 2010, to establish the Climate Technology Centre and Network (CTCN), an operational body to facilitate networking among national, regional, sectoral and international agencies dealing with climate-related technologies.¹⁶

CONCLUSION

Innovative transfer of both technologies and know-how will be required to meet climate change objectives in the context of both mitigation and adaptation. This chapter has identified possible obstacles to the transfer of technology that could arise internationally with respect to intellectual property rights, corporate behaviour and trading rules. Existing agreements sound restrictive, often strongly favouring owners of intellectual property over potential users. To date, these factors have not proved prohibitive. However, they are likely to take on greater significance if developing countries embark on a big push toward a low-emissions, high-growth development pathway.

Anticipating those obstacles and devising ways around them are urgent tasks for the international community. Several creative solutions have been

proposed to make use of existing flexibility, and/or to modify the rules that are now in place. These solutions would require consensus, since they might entail the amendment of WTO rules and the adoption of special climate waivers based on the urgency of the rapidly evolving climate situation. They will also need to pay careful attention to the implications of the WTO principles of non-discrimination and of UNFCCC principles, especially that of common but differentiated responsibilities and capabilities. Since any post-2012 agreement is likely to retain these principles, the challenge will be to ensure the coherence and compatibility of their applications. New mechanisms for international support for technology transfer will be needed in order to ensure the diffusion and application of essential innovations in the countries where they are most needed.

NOTES

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