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Chapter 12 - Innovation Law and Policy Choices for Climate Change-Related Public–Private Partnerships

Joshua D. Sarnoff

Margaret Chon

12 Innovation Law and Policy Choices for Climate Change-Related Public–Private Partnerships

Joshua D. Sarnoff* and Margaret Chon

Introduction

The impacts and costs of climate change will depend substantially upon the rapid development and widespread dissemination of a wide variety of new climate change mitigation and adaptation technologies. A staggering range of technologies emit greenhouse gases (GHGs) or otherwise have climate effects or, on the other hand, can be used to accomplish mitigation or adaption goals. For example, one US study identified hundreds of technologies in various categories, such as "end-use/infrastructure (e.g. transportation), energy supply (e.g. hydrogen), carbon capture-storage (e.g. geologic storage), non-CO2 [carbon dioxide] GHGs (e.g. methane from landfills), [and] measuring & monitoring capabilities (e.g. oceanic CO2 sequestration)."[1] A European study identified fifty-one categories of technology, organized by industry sector, or by conservation or pollution reduction goals.[2] Many other studies have noted that the need for patents or other intellectual property (IP) rights – to induce investment and technology and economic development – may differ dramatically in regard to different kinds of technologies, industry sectors, users, and innovators.[3] Accordingly, the research and

* Some portions of this chapter are drawn from and build upon Joshua D. Sarnoff, *The Patent System and Climate Change*, 16 Va. J. L. & Tech. 301 (2011) [hereinafter Sarnoff, *Patent System*]; Joshua D. Sarnoff, *Government Choices in Innovation Funding (with Reference to Climate Change)*, 62 Emory L. J. 1087 (2013) [hereinafter Sarnoff, *Government Choices*]; Joshua D. Sarnoff, *The Likely Mismatch Between Federal R&D Funding and Desired Innovation*, 18 Vanderbilt J. Enter. & Tech. L. 363 (2016) [hereinafter Sarnoff, *Mismatch*]; Research Handbook on Intellectual Property and Climate Change 200–33, 334–51 (Joshua D. Sarnoff ed., 2016) [hereinafter Sarnoff, Research Handbook]; Joshua D. Sarnoff, *Intellectual Property and Climate Change, with an Emphasis on Patents and Technology Transfer, in* The Oxford Handbook of International Climate Change Law 391–416 (Gray, Kevin R., Richard Tarasofsky, & Cinnamon P. Carlarne eds., 2016); Jesse L. Reynolds, Jorge L. Contreras & Joshua D. Sarnoff, *Solar Climate Engineering and Intellectual Property: Toward a Research Commons*, 18 Minn. J. L., Sci. & Tech. 1 (2017); Joshua D. Sarnoff, *Patent Eligible Inventions after Bilski: History and Theory*, 63 Hastings L. J. 53 (2011); Henrik Holzapfel & Joshua D. Sarnoff, *A Cross-Atlantic Dialog on Experimental Use and Research Tools*, 48 IDEA 123 (2008); Joshua D. Sarnoff & Christopher Holman, *Recent Developments Affecting the Enforcement, Procurement, and Licensing of Research Tool Patents*, 23 Berkeley Tech. L. J. 1299, 1357 (2008).

1 *See, e.g.*, Thomas L. Brewer, *Technology Transfer and Climate Change: International Flows, Barriers, and Frameworks*, in Climate Change, Trade and Competitiveness (Lael Brainerd and Isaac Sorkin eds.) (citing the US Climate Change Technology Program).

2 *Id.* (citing the European Commission Environmental Technologies Action Plan).

3 *See generally*, *e.g.*, Keith E. Maskus & Ruth L. Okediji, *Legal and Economic Perspectives on International Technology Transfer in Environmentally Sound Technologies, in* Intellectual Property Rights: Legal

development (R&D) and IP landscapes for technology transfer regarding climate change technologies is highly heterogenous.

The Paris Agreement (Paris Agreement)[4] of the UN Framework Convention on Climate Change (UNFCCC)[5] obligated significant funding for mitigation and adaptation, which will combine with large potential private markets for mitigation, adaptation, and infrastructure measures. These funds will attract new technological development. The Paris Agreement follows the approach to technology R&D[6] financing and dissemination[7] through various methods – which may include private market flows – adopted by the UNFCCC in Cancún in 2010.[8]

This chapter addresses the choices that government policy-makers and private actors must and will make within the innovation policy system to fund and develop climate change-related mitigation and adaptation technologies (whether or not subject to IP rights) as well as to transfer those technologies around the world to address climate change-related needs. In this chapter, the term "technology transfer" refers to the many methods of disseminating climate-change mitigation and adaptation technologies,[9] even though technology transfer in the UNFCCC and in the Paris Agreement, as well as in some other contexts, may sometimes have a narrower meaning.[10]

The Paris Agreement placed substantial emphasis on R&D and technology transfer through private markets, contrary to competing recommendations to rely more on public funding[11] and despite the many government alternatives that exist for funding technology development and transfer.[12] In particular, governments can play an important role in

and Economic Challenges for Development 392 (2014) [hereinafter Maskus & Okediji, *Legal and Economic Perspectives*]; Keith Maskus & William Ridley, *Intellectual Property-Related Preferential Trade Agreements and the Composition of Trade* (draft of Mar. 17, 2017) (on file with the author); David Autor et al., *Foreign Competition and Domestic Innovation: Evidence from U.S. Patents* (NBER Working Paper No. 22879, Nov. 2016); Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not)* (Nat'l Bureau of Econ. Research, Working Paper No. W7552, 2000) (empirical analysis of differences between products and processes and across industries); Korhan Arun & Durmus C. Yildirim, *Effects of Foreign Direct Investment on Intellectual Property, Patents and R&D*, 7 Queen Mary J. Intell. Prop. 226 (2017); Richard C. Levin et al., *Appropriating the Returns from Industrial Research and Development*, 18 Brookings Papers on Econ. Activity 783 (1987); Katherine J. Strandburg, *Users as Innovators: Implications for Patent Doctrine*, 79 U. Colo. L. Rev. 467, 478 (2008); Michael W. Carroll, *The Problem of Uniformity Cost in Intellectual Property Law*, 55 Am. U. L. Rev. 55, 848 (2008).

4 UNFCCC, *Paris Agreement*, FCCC/CP/2015/L.9/Rev.1, Draft Decision –/CP.21 Annex (2015), [hereinafter Paris Agreement].

5 1771 U.N.T.S. 107, *signed* Jun. 1992, *entered into force* Mar. 21, 1994 [hereafter UNFCCC].

6 R&D is often combined with the term 'demonstration' and referred to collectively as 'RD&D.' Demonstration is often necessary after development in order to assure fitness of the technology for desired purposes.

7 'Dissemination' and 'RD&D' collectively are sometimes referred to as 'RDD&D,' although the term 'deployment' is more frequently used in this context than the broader term 'dissemination.'

8 *See* UNFCCC (2010), Draft Decision CP.16, Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, ¶¶ IV.A.98–99 [hereinafter UNFCCC, Cancún Agreement].

9 See the discussion of the meaning of technology transfer in Part I.A.

10 *Paris Agreement*, *supra* note 4 at Annex, Preamble ¶ 3.

11 *See, e.g.*, Gwyn Prins et al., *The Hartwell Paper: A New Direction for Climate Policy After the Crash of 2009*, 5 (2010). *Cf.* Jomo Kwame Sundaram, Anis Chowdhury, Krishnan Sharma, & Daniel Platz, *Public-Private Partnerships and the 2030 Agenda for Sustainable Development: Fit for Purpose?* 6 (U.N. Dept. of Econ. & Soc. Affairs, DESA Working Paper No. 148, ST/ESA/2016/DWP/148, Feb. 2016) (critically evaluating "blended finance" in public–private partnerships).

12 *See generally* Sarnoff, *Government Choices*, *supra* note *.

stimulating innovation and technology transfer. Mechanisms that are available for governments to fund, develop, and transfer innovations include public provision of necessary infrastructure, subsidized research, and prioritized public procurement. All of these options can substitute for, supplement, or support market-driven intellectual property (IP) rights. But there are limits to government resources (particularly at local levels), and the public sector "does not always have the resources required to push through new projects independent of the IP-related costs involved."[13] Given the political difficulties of committing to massive expenditures as public obligations, the choice to rely primarily on private markets and consequent IP rights to generate the bulk of the committed funding for climate change-related mitigation and adaptation technologies hardly comes as a surprise.

Reliance on private sector development and transfer thus will encourage the acquisition of IP rights (of differing kinds, to differing degrees, and in various industries) in the hopes of appropriating greater economic returns. In turn, the costs of climate change mitigation and adaptation measures will depend in part on whether specific climate change technologies are subject to IP rights, on how those rights are licensed, and on what technological substitutes are affordably available.[14] For example, widely cited assessments have assumed there would be price constraints on patented climate change technologies because of the availability of ready substitutes for existing technologies, or because of development of incremental rather than breakthrough technologies. But these assumptions may not always hold,[15] as climate technologies are very diverse. These assumptions are particularly unlikely to be true if we move to novel geoengineering solutions that have not previously been deployed in markets, such as carbon capture and sequestration technologies or solar climate engineering methods (which include the use of aerosols or marine cloud brightening to increase the Earth's albedo, i.e., reflectivity).[16]

[13] Chatham House Workshop Report, *IPRs and the Innovation and Diffusion of Climate Technologies*, 3 (2007).

[14] *See* John H. Barton, *Intellectual Property And Access To Clean Energy Technologies In Developing Countries: An Analysis Of Solar Photovoltaic, Biofuel, And Wind Technologies* (2007), International Center for Trade and Sustainable Development Issue Paper No. 2, x–xii; John H. Barton, *Mitigating Climate Change Through Technology Transfer: Addressing the Needs of Developing Countries*, Chatham House, Energy, Environment and Development Programme: Programme Paper 08/02, 9–10 (2008); *see also* Copenhagen Economics, *Are IPRs a Barrier to the Transfer of Climate Change Technologies?*, 4 (2009). *Cf.* Bronwyn Hall & C. Helmers, *The Role of Patent Protection In (Clean/Green) Technologies* 7 (National Bureau of Economic Research, Working Paper 16323 (2010).

[15] Maskus & Okediji, *Legal and Economic Perspectives, supra* note 3; *See, e.g.*, Maria J. Oliva et al., *Climate Change, Technology Transfer and Intellectual Property Rights*, International Centre for Trade and Sustainable Development 67 (2008); Keith E. Maskus & Ruth Okediji, *Intellectual Property Rights and International Technology Transfer to Address Climate Change: Risks, Opportunities and Policy Options*, International Centre for Trade and Sustainable Development 10 (2010) [hereinafter Maskus & Okediji, *Intellectual Property Rights*].

[16] *See generally* World Energy Council, *World Energy Resources: Carbon Capture and Storage 2016*; Jesse L. Reynolds, *Solar Climate Engineering, Law, and Regulation*, *in* The Oxford Handbook on the Law and Regulation of Technology 799–822 (Roger Brownsword, Eloise Scotford, & Karen Yeung eds., 2016); Edward A. Parson, *Starting the Dialog on Climate Engineering Governance: A World Commission*, Centre for International Governance Innovation. *But cf.* Jeffrey Rismann & Robbie Orvis, *Carbon Capture and Storage: An Expensive Option for Reducing U.S. CO2 Emissions*, Forbes (May 3, 2017). Note that some cost-effective and efficient geoengineering techniques are very old, and geoengineering approaches could simply promote natural processes. *See, e.g.*, R.D. Schuiling & Oliver Tickel, *Olivine Against Climate Change and Ocean Acidification*, Innovation Concepts (n.d.), available at: http://www.innovationconcepts.eu/res/literatuurSchuiling/olivineagainstclimatechange23.pdf (last visited June 12, 2018).

All of these factors take on renewed significance and urgency when considered in light of the UN Sustainable Development Goals (SDGs), adopted in September 2015 as part of the 2030 Agenda for Sustainable Development (2030 Agenda).[17] SDG 9 commits member states to "promote inclusive and sustainable industrialization and foster innovation,"[18] while SDG 13 commits them to "[t]ake urgent action to combat climate change and its impacts."[19] And as SDG 17 indicates, all of the SDGs are to be implemented through partnerships comprised of heterogenous institutions – including private sector partners (whether for profit or nonprofit) that may not be primarily oriented toward sustainable development.[20] The overall global landscape of climate change and of energy technology innovation and transfer already is populated by public–private partnerships (PPPs),[21] reflecting various forms of ownership of and control over those technologies.[22] Many more such partnerships are anticipated to form. In light of this reality, it is interesting how few extant analyses are available of the likely impact of the increased private sector involvement in development-oriented efforts addressing climate change through R&D and technology transfer.[23]

The emphasis on PPPs to achieve the SDGs, including use of PPPs to address climate and energy SDGs, requires careful calibration of the many different law and policy choices.[24] This chapter refers to policies underlying climate change-related innovation laws as "innovation policies." It refers to governmental and private choices made to effectuate the laws as well as related administrative or private policies as "innovation choices." Both public sector and private sector innovation policies can permit, encourage, and/or generate innovation choices, which choices in turn can be exercised by either or both public sector and private sector partners within particular technology environments. Critical among the many possible laws and policies shaping innovation are those that relate to innovation funding choices.

[17] U.N. Dep't of Econ. and Soc. Affairs, Sustainable Development Knowledge Platform, *Transforming Our World: The 2030 Agenda for Sustainable Development*, https://sustainabledevelopment.un.org/post2015/transformingourworld (last visited June 12, 2018).

[18] *Id.*, *Sustainable Development Goal 9*, https://sustainabledevelopment.un.org/sdg9.

[19] *Id.*, *Sustainable Development Goal 13*, https://sustainabledevelopment.un.org/sdg13.

[20] *Id.*, *Sustainable Development Goal 17*, https://sustainabledevelopment.un.org/sdg17.

[21] Some of these PPPs are analyzed in other chapters in this volume. *See* Ahmed Abdel-Latif, chapter 11, *supra*; Ayşem Mert & Philipp Pattberg, chapter 13, *infra*.

[22] *See generally* Geertrui Van Overwalle, *Individualism, Collectivism and Openness in Patent Law: Promoting Access Through Exclusion*, in Individualism and Collectiveness in Intellectual Property Law (Jan Rósen, ed., 2011) (discussing various forms of multiple ownership and various licensing approaches available for use by those forms).

[23] Cf. Carolyn Deere-Birkbeck, *Global Governance in the Context of Climate Change: The Challenges of Increasingly Complex Risk Parameters*, 85 Int'l Affairs 1173, 1191–92 (2009).

[24] Some have used the term "eco-innovation" to address innovation management within the climate change technology arena. *See, e.g.*, Cristina Díaz-García, Ángela González-Moreno & Francisco J. Sáez-Martínez, *Eco-Innovation: Insights From a Literature Review*, 17 Innovation: Organization & Management 6 (2015), (defining "eco-innovation" as the "production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation [developing or adopting it] and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use [including energy use] compared to relevant alternatives"; also performing literature review and identifying areas of further research in eco-innovation studies).

While the objects of "law" and "policy" often result from public sector choices, the hybrid nature of PPPs[25] requires adoption of both public sector and private sector policies and choices in a wider range of contexts, including in the public or private production of public goods. For simplicity of exposition, we refer below interchangeably to "innovation policy choices," "innovation policies," and "innovation choices," although we may mean in context: (1) choices by government entities to adopt particular laws or policies; (2) choices by PPPs or private sector entities to adopt particular requirements or policies; (3) choices made by the relevant public sector, hybrid, or private sector entities pursuant to those laws, requirements, or policies (e.g., decisions regarding what price to charge, whether to license exclusively or nonexclusively, and whether to develop technology or to allow others to do so); or (4) a combination of these choices.

Innovation policy choices, including government funding choices, are embedded in the structure and decisions of institutions, including PPPs. Made by the people that comprise those institutions, such choices are shaped by the networks in which these institutions are located and by the power arrangements that the institutions reflect.[26] Partners within collaborative networks may sometimes seek to achieve different and/or possibly conflicting innovation goals, rendering particular innovation policy choices suboptimal or ineffective. Conversely, the institutions may align in ways that cause particular forms of innovation policy choices, including funding, to be better choices than alternatives that – all things being equal – otherwise might be considered preferable.[27] For all these reasons, collaborative networked institutions, such as development-oriented PPPs, should coordinate with the overall global governance and policy-making framework led by decisions of national, state, and local governments, as well as of intergovernmental organizations (INGOs). Steering by these various public sector partners are more likely to maximize the public goods outputs of PPPs and to better achieve the SDGs.

Unfortunately, far too little is yet known about the mechanisms by which hybrid institutions such as PPPs might optimally be structured so as to best encourage the development and transfer of climate change-related technologies.[28] To begin to address

[25] Tanja A. Börzel & Thomas Risse, *Public-Private Partnerships: Effective and Legitimate Tools of Transnational Governance?*, *in* Complex Sovereignty: Reconstituting Political Authority in the Twenty-First Century 195, 196 (Edgar Grande & Louis W. Pauly eds., 2005) ("Transnational PPPs . . . [are] institutionalized cooperative relationships between public actors (both governments and international organizations) and private actors beyond the nation-state for governance purposes. By governance purposes, we mean the making and implementation of norms and rules for the provision of goods and services that are considered to be binding by members.").

[26] See, e.g., Walter W. Powell, Jason Owen-Smith, & Laurel Smith-Doerr, *Sociology and the Science of Science Policy*, in The Science Of Science Policy: A Handbook 56–57 (Kaye H. Fealing et al. eds., 2011) (defining "institutions" as "the formal and informal rules and conventions that guide a great deal of social life," "networks" as "patterned relationships that connect both individual and organizational participants in a field," and "power relations" as "particular, asymmetric forms of network ties"). *See generally* Sarnoff, *Mismatch*, *supra* note *.

[27] *See, e.g.*, Amy Kapczynski, *The Cost of Price: Why and How to Get Beyond Intellectual Property Internalism*, 59 UCLA L. Rev. 970, 996–97 (2012) (noting that intellectual property rations access according to price, whereas "the background allocation of resources may be unjust" and arguing that it is debatable that efficiency goals should be prioritized over distributive justice, but in any event it has not been shown that intellectual property approaches and reliance on price is a more efficient innovation strategy).

[28] *See, e.g.*, Angela Triguero, Lourdes Moreno-Mondéjar, & Maria A. Davia, *Eco-Innovation By Small And Medium-Sized Firms In Europe: From End-Of-Pipe To Cleaner Technologies*, 17 Innovation: Org. &

this knowledge gap, Part I of this chapter first briefly discusses some of the global inequalities that likely will result from existing unequal patterns of creation and distribution of climate change technologies and associated ownership of IP rights. This section also discusses how the costs of accessing climate change technologies protected by IP rights may further exacerbate the current unequal impacts and differential climate change obligations of countries. Without concerted efforts to change existing innovation laws and policies, including funding choices, the corresponding costs of these impacts and obligations may impose significant stresses on the IP system, as they have with other serious global problems such as with access to essential medicines.[29]

Part II then explains how PPPs pose significant challenges for specific policy choices regarding innovation funding of climate change technologies and associated IP. To do so, it first presents a typology of public sector choices in innovation funding, including decisions to rely on the private sector for funding. This section then explains how these basic national policies may affect the nature, direction, and roles of PPPs in the climate change and energy development domains. The policy choices for innovation funding proposed in this Part are relevant both to increasing domestic innovation capacity for climate change R&D as well as to technology transfer across jurisdictions.

Part III explains why the geographical imbalances of wealth and innovation capacity discussed in Part I may pose serious problems for technology transfer, particularly when attempting to leverage PPP efforts across jurisdictional borders. It then proposes three sets of approaches to overcoming innovation, access, and price constraints that may result from public sector policies that rely primarily on PPPs, on private markets, and on IP rights to fund the development and transfer of climate change-related technologies. These approaches include public sector innovation laws and policies as well as innovation choices made within the private sector (or by governments or PPPs acting as proprietors).[30] Similarly, greater involvement of local actors in adapting technologies to local conditions will normally be needed for effective and efficient

Mgt. 24 (2015) (finding, for example, that "[n]etwork involvement measured by cooperation with universities and research agencies is essential in ... eco-innovation in small firms, but not for mid-sized firms. With regard to environmental regulation, subsidies are important only for small firms, especially for the adoption of cleaner technologies. On the contrary side, existing environmental regulation is a key factor to explain the adoption of cleaner technologies for medium firms but not for smaller ones."); Chulhyun Kim and Moon-Soo Kim, *Identifying Core Environmental Technologies Through Patent Analysis*, 17 Innovation: Org. & Mgt. 139–158 (2015).

29 *See* Ahmed Abdel-Latif et al., *Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward*, International Centre for Trade and Sustainable Development Policy Brief No. 11 (November 2011).

30 Although some of the proposals are best addressed to developed countries like the United States, others may be better addressed to developing countries or private sector actors (such as universities), or may depend on the particular laws and policies in place in those countries. And although these recommendations are made by two academics located in the United States, we believe they have broader application, even if they may require tailoring to the conditions and needs of different countries or of particular PPPs or private sector entities. For example, as discussed in Part III, some countries have legal regimes where private entities are entitled to take title to patented inventions generated with governmental innovation funds; other countries may not. Similarly, the 'international exhaustion' requirements adopted by various countries (or regions) may differ. Accordingly, careful thought should be given to modifying these proposals as appropriate to the context of particular countries and private-sector practices.

technology transfer, particularly for determining which technologies should be transferred, modified, or developed.[31]

The chapter concludes with a renewed call for greater public funding[32] and for more careful management of the innovation policies and innovation choices made in establishing and operating climate change-related PPPs.

I Climate Change Technology Transfer and Intellectual Property Inequality

A *Climate Change Technology Transfer under the UNFCCC*

The amount of greenhouse gases that have been emitted over time and the extent of climate change impacts they will cause are unequally distributed by country and by levels of economic development.[33] The United States and the European Union alone account for over 50 percent of the cumulative emissions of carbon dioxide (CO_2) that has occurred from 1850 to 2011.[34] China was the third largest cumulative emitter from 1850 to 2011, and has become the largest worldwide emitter of CO_2.[35]

In 1992 (and earlier), the United Nations (UN) recognized both these inequalities and the unequal abilities of countries to address climate change and to finance responses while simultaneously addressing other social needs. The UNFCCC thus explicitly adopted the principle of "common but differentiated responsibilities and respective capabilities" for addressing climate change.[36] The UNFCCC imposed obligations for the countries principally responsible for climate change to transfer funds and technology to the developing world, and made compliance with UNFCCC mitigation and adaptation goals by developing countries contingent on the fulfillment of those developed country obligations.

[31] Padmashree Gehl Sampath & Pedro Roffe, *Unpacking the International Technology Transfer Debate: Fifty Years and Beyond Research*, ICTSD Issue Paper No. 36, 17, 19 (Nov. 2012). ("[T]echnological learning is domestically induced through a range of proactive policy choices, which are critical to explain the technological underpinnings of export success stories ... National capabilities are not simply built on the basis of R&D and science capacity, but are fostered through linkages of economic and non-economic agents within the economy. Such a policy framework therefore involves purposive sets of actions by national governments to promote innovation capacity. These policy actions are aimed at strengthening linkages and collaborative bonds between a variety of actors and networks in the economy.")

[32] Recent economic scholarship emphasizes the substantial returns to government funding of the innovation system, not only through direct government funding of both basic and applied research but also through tax credits for private investments in research and development. *See Returns to Federal Investments in the Innovation System: Proceedings of a Workshop – in Brief*, National Academies of Science, Engineering & Medicine (Oct. 2017).

[33] *See, e.g.*, *Fifth Assessment Synthesis Report, Summary for Policymakers*, Intergovernmental Panel on Climate Change (IPCC) at 14 (2014) ("Regional Key Risks and Potential for Risk Reduction").

[34] *See, e.g.*, Mengpin Ge et al., *6 Graphs Explain the World's Top 10 Emitters* (Cumulative CO_2 Emissions 1850–2011), World Resources Institute (2014).

[35] *See, e.g.*, *id.*; *see also Global Greenhouse Gas Emission Data*, US Environmental Protection Agency (EPA) (2016).

[36] UNFCCC, *supra* note 5, Preamble ¶ 6 ("*Acknowledging* that the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions"). *See, e.g.*, *id.* Art. 3.1.

Article 4.5 of the UNFCCC obligated developed countries to "promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention" designed to mitigate and adapt to climate change.[37] These environmentally sound technologies (ESTs)[38] are therefore central to the obligations under the UNFCCC. Similarly, Article 4.7 of the UNFCCC provided that:

> [t]he extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.[39]

The 2015 Paris Agreement of the UNFCCC reiterated the Framework Convention's recognition of the inequality of causes, impacts, and obligations regarding climate change.[40] It also reinforced the obligation of developed countries to "provide financial resources to assist developing country Parties with respect to both mitigation and adaptation in continuation of their existing obligations under the [UNFCCC]."[41] The parties to the Paris Agreement agreed to meet voluntarily pledged mitigation goals,[42] and for developed country parties to transfer at least US$100 billion per year until 2025, as well as to transfer technologies to developing country parties for their mitigation and adaptation activities.[43]

Notably for purposes of this chapter, the funds committed by countries under the Paris Agreement will include a mix of private and public sources, and will go to both products and services in the form of technology transfers. Vast amounts of money, mobilized in part by the prospect of large commercial markets and prompted in part by governmental development funding, thus will be spent in the energy, transport, agriculture, forestry, and other industrial and social sectors. Some of that funding will go toward infrastructure development.[44] Nevertheless, the promised funds under the UNFCCC are substantially

[37] UNFCCC, *supra* note 5, Art. 4.5.

[38] The transfer and adaptation of effective technologies to developing countries on a sustainable basis is necessary to address the adverse affects of climate change. As noted in Article 4.5 of the UNFCCC, developed countries are required to promote and help finance international technology transfer and access to environmentlally sound technologies and know-how to enable developing countries to implement the provisions of the Convention. *See* Maskus & Okediji, *Legal and Economic Perspectives*, *supra* note 3, at 392.

[39] UNFCCC, *supra* note 5, Art. 4.7.

[40] *See Paris Agreement*, *supra* note 4, Preamble ¶ 3 ("*In pursuit* of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.").

[41] *Id.*, at Art. 9.1.

[42] *See Paris Agreement*, *supra* note 4, Art. 3, Art. 4, ¶¶ 2, 3, 8, 11–14, Art. 6, ¶ 1.

[43] *See Paris Agreement*, *supra* note 4, Arts. 9, 10; Draft Decision –/CP.21, ¶¶ 54, 67–68.

[44] *Cf.* Manuel F. Montes, *Industrialization, Inequality and Sustainability: What Kinds of Industry Policy Do We Need?*, South Center Policy Brief (Aug. 2017) (discussing postcolonial-era challenges to the SDG 9 commitment to "build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation," in light of the current structure of United Nations' development assistance, international legal structure, and institutions).

less than the amounts that were thought needed by World Bank estimates in 2009,[45] and by the substantially higher estimates that have been developed since,[46] particularly in light of new information on the rapidly accelerating changes to the climate.[47]

Technology transfer occurs in many different forms. As a working group of the Intergovernmental Panel on Climate Change (IPCC) defined it, technology transfer is:

> 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 ... the broad and inclusive term 'transfer' encompasses diffusion of technologies and technology cooperation across and within countries. It covers technology transfer processes between developed countries, developing countries, and countries with economies in transition. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies.[48]

Since the 2010 Conference of the Parties in Cancún, the UNFCCC has focused its technology transfer efforts through new subsidiary institutions: the Technology Executive Committee (TEC) and the Climate Technology Center and Network (CTCN), and the Green Climate Fund (GCF).[49] The Paris Agreement continues to employ and to rely on these organs formed under the UNFCCC.[50] Some of their mechanisms for facilitating technology transfer are described in Box 12.1.

[45] *See World Development Report 2010: Development and Climate Change*, World Bank 6–7 (2009) [hereinafter World Development Report 2010].

[46] *See* United Nations Environment Programme (UNEP), *The Adaptation Gap Finance Report 2016*, at 3 (May 2016) (needs 2–3 times higher than World Bank estimates of $70–100 billion/year by 2030; 4–5 times higher by 2050).

[47] *See, e.g.*, Christiana Figueres et al., *Comment: Three Years to Safeguard Our Climate*, 546 Nature 593 (Jun. 29, 2017); *Earth's Oceans are Warming 13% Faster Than Thought, and Accelerating*, The Guardian (Mar. 10, 2017).

[48] Stephen O. Andersen et al., *Technical Summary*, *in* Methodological and Technological Issues in Technology Transfer: A Special Report of IPCC Working Group III 15–16 (2000).

[49] "The TEC consists of 20 technology experts representing both developed and developing countries ... The CTCN is hosted by the United Nations Environment Programme in collaboration with the United Nations Industrial Development Organization, and is supported by 11 partner institutions. The Centre facilitates a network of national, regional, sectoral and international technology centres, networks, organizations and private sector entities." UNFCCC, *Support for Implementing Climate Technology Activities*, TT:CLEAR, http://unfccc.int/ttclear/support/technology-mechanism.html. The partners include universities and private foundations. *See, e.g., Consortium Partners*, CTCN, www.ctc-n.org/about-ctcn/consortium-partners (last visited Oct. 10, 2017). The GFC's role continues to grow as the largest international climate fund helping developing countries respond to climate change. *See GFC in Numbers*, Green Climate Fund, 2017.

[50] *See Paris Agreement*, *supra* note 4, Art. 10, ¶ 3; *id.* Draft Decision –/CP.21, ¶¶ 55, 59, 64. The TEC and the CTCN form the Technology Mechanism serving the Paris Agreement; the TEC plays a key role in supporting countries to identify climate technology policies that help them to achieve the Agreement's objectives. The CTCN promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. *See TT:CLEAR*, http://unfccc.int/ttclear/support/technology-mechanism.html.

Box 12.1. UNFCCC Mechanisms for Facilitating Technology Transfer

The TEC has adopted six principal 'modalities' for technology development and transfer[51] and has prioritized efforts to perform 'technology needs assessments' and to understand better the barriers to technology transfer.[52] Similarly, the CTCN, which is currently being hosted by the United Nations Environment Programme (UNEP),[53] has adopted modalities and procedures in six areas, including facilitating the financing of the activities.[54] The GCF, in turn, has focused so far on developing the mechanisms of funding for mitigation and adaptation (including technology transfers), and on encouraging a balance of funding for mitigation and adaptation needs. The GCF established its Secretariat with the UNFCCC and the Global Environment Facility (GEF),[55] created a Financial Intermediary Fund with the World Bank as interim trustee, and authorized the Republic of Korea to be the more permanent host for the GCF.[56]

The UNFCCC as a whole has called for developed countries to expedite their short-term ('fast-track') funding and to scale up their commitments to long-term funding to developing countries (earlier to US$100 billion by 2020, and in Paris to treat that amount as a 'floor' and continue it at least through 2025).[57] These funds (even if ultimately provided) are likely to be much too low to achieve the Paris Agreement's stated goal of limiting temperature increases to no more than two-degrees Celsius above pre-industrial levels, much less to achieve the more ambitious one-and-one-half degree Celsius goal in light of recent acceleration of warming effects.[58] The UNFCCC has also called for a "significant share" of the new multilateral funding for adaptation activities to "flow through" the GCF, and for developed countries to "channel a substantial share of public funds" to

[51] These are "(a) Analysis and synthesis; (b) Policy recommendations; (c) Facilitation and catalysing; (d) Linkage with other institutional arrangements; (e) Engagement of stakeholders; [and] (f) Information and knowledge sharing." *Report of the Conference of the Parties on its Seventeenth Session, Held in Durban from 28 November to 11 December 2011*: *Decision 4/CP.17 Technology Executive Committee – Modalities and Procedures*, UNFCCC, Report No. FCCC/CP/2011/9/Add.1 ¶ 4 (a)-(f) (2011) [hereinafter UNFCCC, "COP17 Report"].

[52] *See Report of the Conference of the Parties on its Eighteenth Session, Held in Doha from 26 November to 8 December 2012*, UNFCCC, Report No. FCCC/CP/2012/8/Add.2. ¶ 10, (2012) [hereinafter UNFCCC, "COP18 Report"].

[53] *Id.*, at Decision 14/CP.18, *Arrangements to make the Climate Technology Centre and Network Fully Operational*.

[54] The other five are: "(a) identifying currently available climate-friendly technologies for mitigation and adaptation that meet development needs; (b) facilitating the preparation of project proposals for existing technologies for mitigation and adaptation; (c) facilitating adaptation and deployment of currently available technologies to meet local needs and circumstances; (d) facilitating research, development and demonstration of new climate-friendly technologies for mitigation and adaptation; (e) enhancing human and institutional capacity to manage the technology cycle . . ." *See* UNFCCC, COP17 Report, *supra* note 51, at Decision 2/CP.17, *Outcome of the work of the Ad Hoc Working Group on, Long-term Cooperative Action under the Convention*, ¶ 135(a)-(f).

[55] The GEF structure is more complex than the TEC; it includes scientific and technical advisory panels of "internationally recognized experts in the GEF's key areas of work . . . [which are] are supported by a global network of experts and institutions." *Organization*, GEF, www.thegef.org/about/organization.

[56] *See* UNFCCC, COP18 Report, *supra* note 52 at Decision 6/CP.18, *Report of the Green Climate Fund to the Conference of the Parties and Guidance to the Green Climate Fund*, preamble and ¶¶ 3, 7(b).

[57] *See Paris Agreement*, *supra* note 4, at Draft Decision –/CP.21, ¶ 54.

[58] *See id.*, at Art. 2.1(a); US Global Climate Change Research Program, *Climate Science Special Report* (CSSR) (Jun. 28, 2017), www.nytimes.com/packages/pdf/climate/2017/climate-report-final-draft-clean.pdf.

such activities.[59] The Paris Agreement recognizes the need for developed countries to "provide financial resources to assist developing country Parties with respect to both mitigation and adaptation" and to "take the lead in mobilizing climate finance from a wide variety of sources, instruments, and channels, noting the significant role of public funds."[60] Significantly, as noted by the TEC in its 2012 Report, "[i]ntellectual property rights were identified as an area for which more clarity would be needed on their role in the development and transfer of climate technologies based upon evidence on a case by case basis."[61] However, the Paris Agreement does not itself mention IP rights.

B *Unequal Climate Technology R&D and Patent Ownership*

Most new, patented mitigation and adaptation technologies are being invented in a small group of developed countries (collectively referred to as the "North") and a few emerging economy countries – particularly Brazil, Russia, India, China, South Korea, and Mexico (referred to as the "BRICs-plus" countries), rather than in the developing world (collectively referred to along with emerging economy countries as the "South").[62] More specifically, the first tier of climate change technology development includes principally Japan, Germany, and the United States (the "Big Three") for a very wide range of technologies, and the United Kingdom and France for particular sectors such as energy generation. Through self-conscious planning and large amounts of government funding, China soon may reach the point of creating "Big Four" status.[63] The second tier includes the BRICS-plus countries, which are preeminent in specific sectors such as cement or renewable energy technologies.[64]

[59] *See* UNFCCC, COP18 Report, *supra*, note 52, at Decision 1/CP.18, *Agreed outcome pursuant to the Bali Action Plan*, ¶¶ 63–68. *See also Report of the Conference of the Parties on its Nineteenth Session, Held in Warsaw from 11 to 23 November 2013*: *Decision 3/CP19*, *Long-term Climate Finance*, UNFCCC, Report No. FCCC/CP/2013/10/Add.1 ¶¶ 7–9 (2013); *Paris Agreement*, *supra* note 4, at Draft Decision –/CP.21, ¶ 55, 59.

[60] *Paris Agreement*, *supra* note 4, at Art. 9, ¶¶ 1, 3.

[61] *Report on Activities and Performance of the Technology Executive Committee for 2012*, UNFCCC, Report No. FCCC/SB/2012/2 ¶ 35(g) (2012).

[62] *See*, *e.g.*, Antoine Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale*: *A Study Drawing on Patent Data* 4 (CERNA, Mines Paris Tech, Agence Française de Dévelopment, Working Paper, 2008) [hereinafter Dechezleprêtre 2008a], https://sallan.org/pdf-docs/Dechezlepretre.pdf; Bernice Lee, Ilian Iliev & Felix Preston, *A Chatham House Report: Who Owns Our Low Carbon Future?: Intellectual Property and Energy Technologies*, Royal Institute of International Affairs, viii (2009); UNEP, European Patent Office, (EPO) and International Centre for Trade and Sustainable Development (ICTSD), *Patents and Clean Energy: Bridging the Gap Between Evidence and Policy: Final report*, 9, 30–36 (2010) [hereinafter UNEP/EPO/ICTSD Study]. A recent patent study confirmed these continuing disparaties between the North and South, as well as found an emphasis on pollution control rather than energy efficiency technologies. *See generally* Gemma Durán-Romero & Ana Urraca-Ruiz, *Climate Change and Eco-Innovation. A Patent Data Assessment of Environmentally Sound Technologies*, 17 Innovation: Org. & Mgmt. 115 (2015).

[63] *See generally*, Cheung, Tai Ming, et al. (Univ. of Cal. Institute on Global Conflict and Cooperation), *Planning for Innovation: Understanding China's Plans for Technological, Energy, Industrial, and Defense Development* (2016).

[64] *See* Dechezleprêtre 2008a, *supra* note 62, at 3–4; Lee, Iliev & Preston, *supra* note 62, at viii; UNEP/EPO/ICTSD Study, *supra* note 62, at 30–36.

Between 1978 and 2003, most of the climate change mitigation technologies developed and patented in thirteen categories – as measured by data from the EP/OECD World Patent Statistical Database – came from the Big Three, although in two categories the BRICS-plus countries were increasingly developing patented technologies.[65] In particular, China has been spending extensively on R&D and consequently has been patenting more.[66] From 1998 to 2003, patenting of climate change technologies grew on average by 9 percent per year overall and 18 percent for emerging economies.[67] The Big Three accounted for roughly 60 to 85 percent of all patented inventions in all categories measured.[68] Japan alone accounted for over 50 percent in three categories.[69]

These unequally distributed technology developments reflect gains from specialization that are likely to continue or to heighten existing imbalances of technological sophistication and wealth accumulation through "clustering" effects.[70] "Specialization gains are seemingly important in climate change innovation,"[71] and various countries (particularly Japan) have a substantial, existing competitive advantage in regard to green technology development.[72] These imbalances in local patenting also may reflect differences in R&D budgets[73] and in the head start that many developed countries already possess in scientific and technological development.

Although it is widely recognized that greater public financing for R&D (particularly for low-carbon R&D) is needed, it may be difficult to generate the political will to achieve the needed consistent levels of funding or to raise prices sufficiently on carbon emissions to induce private R&D.[74] This could change quickly, however, with growing recognition of the rapidly increasing harms and costs of climate change. It is to be hoped

[65] *See* Dechezleprêtre 2008a, *supra* note 62, at 26.

[66] *See, e.g.*, Yahong Li, Imitation to Innovation in China: The Role of Patents in Biotechnology and Pharmaceutical Industries 70 (2010).

[67] *See* Dechezleprêtre 2008a, *supra* note 62, at 3–4.

[68] *See ibid.* at 18 & Table 3. *See also* Antoine Dechezleprêtre et al., *Invention and Transfer of Climate Change-Mitigation Technologies: A Global Analysis*, 5 Rev. Envt'l. Econ. Pol'y 109, 115–16 (2011) (Big Three accounted for 59% of patented worldwide climate mitigation inventions from 2000–2005, and 53% of high-value inventions).

[69] *See* Dechezleprêtre 2008a, *supra* note 62, at 16.

[70] *See, e.g.*, Michael E. Porter, *Clusters of Innovation: Regional Foundations of U.S. Competitiveness*, Council on Competitiveness (2001); Jonathan Sallet et al., *The Geography of Innovation: The Federal Government and the Growth of Regional Innovation Clusters*, Science Progress 1 (2009).

[71] Antoine Dechezleprêtre et al., *Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale: A Study Drawing on Patent Data* 4 (CERNA, Mines Paris Tech, Agence Française de Dévelopment, Working Paper, November 2008).

[72] *See, e.g.*, Sam Fankauser et al., *Who Will Win the Green Race? In Search of Environmental Competitiveness and Innovation*, 23 Global Envtl. Change 902, 906 (2013).

[73] *See, e.g.*, Carlos M. Correa, *Review of the TRIPS Agreement: Fostering the Transfer of Technology to Developing Countries*, 2 J. World Intel. Prop. 939, 944 (1999).

[74] *See, e.g.* Antoine Dechezleprêtre & D. Popp, *Fiscal and Regulatory Instruments for Clean Technology Development in the European Union*, London Sch. of Econ. & Pol. Sci., Policy Paper, at 10, 18–20 (Jul. 2015) (discussing the "double externality" problem that results in underfunding environmental R&D, noting that carbon pricing may be too low to induce desired levels of R&D, and that positive spillovers from clean technologies are sufficiently large to justify greater R&D subsidies); Antoine Dechezleprêtre et al., *Climate Change Policy, Innovation, and Growth*, London Sch. of Econ. & Pol. Sci., (2016) at 9–19 (discussing competitiveness advantages and R&D funding for clean technology spillovers).

that Paris Agreement efforts through the TEC and GCF will more rapidly generate greater and more widespread international support for increased public R&D financing.

The principal emphasis on private markets and patent rights to develop needed climate change technologies will likely generate substantial trade tensions. These will arise as IP protected goods flow from the North to the South, while revenues from the sale of those technologies may flow in the opposite direction.[75] The costs of such technology transfers thus will result in significant wealth transfers that will run against the flow of the UNFCCC's technology transfer and financing obligations based on "common but differentiated responsibilities and respective capabilities." As in areas outside of climate change technologies, the geographic imbalances in patenting behaviors are likely to further exacerbate existing IP, trade, and scientific differences, as well as to generate political tensions along the North–South divide. Further, the reliance principally by the North on private funding, private markets, and the patent system, and the varying benefits of the patent system for the wide range of technologies and markets in the South,[76] may pose additional challenges to technology transfer.[77] These patterns in the transfer of climate change technology are a familiar, if more recent, example of a long history regarding technology transfer between the North and South more generally.[78]

This is the background against which PPPs have been proposed as a principal means of implementation for the SDGs, which specifically include combatting climate change under SDG 13. The next section explores a particularly important subset of public and private innovation policy choices, i.e., innovation funding mechanisms, that will be used to address climate change-related technology development and transfer.[79]

II Innovation Funding Policies and Choices for Climate Change-Technology Development and Transfer

A *Sustainable Development via PPPs Raises New Questions about the Funding Structure of Climate Change-Related Technology Development and Transfer*

The Paris Agreement supplements the UN Framework Convention on Climate Change to make even clearer the link between sustainable development and environmental protection in regard to climate change. Specifically, the Agreement's objectives for mitigation, adaptation, and financing efforts (and, implicitly, for technology transfer) make this link explicit. It is worth repeating the language here:

[75] *See generally* David A. Gantz & Padideh Ala'i, *Climate Change Innovation, Products and Services Under the GATT/WTO System*, *in* Sarnoff, Research Handbook, *supra* n. * at 271; WTO & United Nations Environment Programme (UNEP), *Trade and Climate Change WTO-UNEP Report* (2009).

[76] *See, e.g.*, Ricardo Cavazos & Douglas Lippoldt, *The Strengthening of IPR Protection: Policy Complements*, 2 W.I.P.O. J. 99, 101–2, 110–12 (2010).

[77] *See, e.g.*, Brewer, *supra* note 1, at 3–5.

[78] Sampath & Roffe, *supra* note 31.

[79] The following section is largely taken from International Council on Human Rights Policy, *Beyond Technology Transfer: Protecting Human Rights in a Climate-Constrained World*, in Sarnoff, Research Handbook, *supra* note *, at 126.

> This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, *in the context of sustainable development and efforts to eradicate poverty*, including by:
>
> (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would *significantly reduce the risks and impacts of climate change*;
> (b) Increasing *the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production*;
> (c) Making finance flows consistent with a pathway towards *low greenhouse gas emissions and climate-resilient development*.[80]

As stated earlier, many different climate change and energy technologies potentially fall within the scope of achieving such sustainable development efforts for climate change mitigation and adaptation. Article 4.5 of the UNFCCC and Paragraph 68(d) of the Paris Agreement encourage such technologies for adaptation to be "environmentally sound."[81] This concern is necessarily of a different kind than same requirement for "environmentally sound" technologies (ESTs) with regard to mitigation technologies. Whereas mitigation technologies must necessarily aim at an ideal horizon of carbon neutrality, ESTs for adaptation must aim at global benchmarks recognizing local variations of development and of need. Adaptation technologies must reflect best available environmental standards in current use, given costs, resources, and the urgency of adaptation. Thus, it is critically important to examine how government funding traditionally has operated in technology transfer generally, and how different funding and coordination approaches might impact the direction of PPPs engaged in climate change and energy innovation and technology transfer.

B *Taxonomy of Government Innovation Funding Mechanisms and Their Relationship to PPPs*

PPPs by definition involve some degree of public sector involvement, including possible funding, policy-making, steering and operational control, and oversight.[82] But very little analytic work has been done to elucidate the various specific mechanisms of government involvement in and governance of PPPs.[83] This is especially true of innovation policy

[80] *Paris Agreement*, *supra* note 4, Art. 2.1(a) (emphasis added).

[81] UNFCCC, *supra* note 5, Art. 4.5 ("The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."); *Paris Agreement*, *supra* note 4, at ¶68(d) ("The enhancement of enabling environments for and the addressing of barriers to the development and transfer of socially and environmentally sound technologies").

[82] This section is substantially condensed from the Joshua D. Sarnoff, *Government Choices*, *supra* note *. For a more detailed analysis, please refer to that discussion.

[83] A notable exception is the historic and developing literature on "commons" institutions that are PPPs. *See, e.g.*, Elinor Ostrom, Governing the Commons: The Evolution of Institutions for Collective Action (Political Economy of Institutions and Decisions, 1990); Governing Knowledge Commons (Brett M. Frischmann, Michael J. Madison, & Katherine J. Strandburg eds., 2014) [hereinafter Governing Knowledge Commons].

choices involving funding choices for technology innovation funding and transfer. Using a broad brush for classification, government choices to fund innovation can be grouped into five categories: (1) subsidization; (2) procurement; (3) direct development; (4) constructed commons; and (5) product, process, and market regulation (which affect the flows of private funding to and within markets).[84] There is no magic to this proposed classification; different categories are reasonable to employ, particularly as some of the contents of the categories may overlap.[85] The five categories listed above reflect five fundamentally different approaches to funding innovation. Some of these categories may have more obvious impact than others on technology innovation and transfer within PPPs. But all are discussed briefly below.

1 Subsidies

Subsidization is a very broad class that has different comparative effects on innovation.[86] The most basic form of subsidy to R&D and innovation is (1) direct and targeted subsidization of R&D and innovation efforts, such as government agency funding of university, corporate, or small business R&D, and government support for education more broadly.[87] Other subsidies include: (2) prizes, rewards, and other *ex post* development funding; (3) consumption or production subsidies; (4) tax subsidies; (5) administrative subsidies; and (6) foreign aid.

The choices that government can make among the various kinds of subsidies should depend on the degree to which the innovation outputs can reliably be predicted; the commercial nature of the research; and the comparative effectiveness of government administrators and firm actors in making predictions, directing the R&D and generating innovation outputs.[88] It will also depend in part on World Trade Organization (WTO) R&D subsidy disciplines.[89] Targeted R&D tax subsidies (and the *ex ante* incentives they generate) are useful principally for profit-making ventures, and they will leave control of

[84] *See* Michael Madison, Brett M. Frischmann, & Katherine Strandburg, *Constructing Commons in the Cultural Environment*, 95 Cornell L. Rev. 657, 667 (2010); Tuomas Takalo, *Rationales and Instruments for Public Innovation Policies*, Bank of Finland Research Discussion Papers, Paper No. 1, 10–19 (2013), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2217502; Michael W. Carroll, *One Size Does Not Fit All: A Framework for Tailoring Intellectual Property Rights*, 70 Ohio St. L.J. 1361, 1368 (2009); Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 Vt. L. Rev. 347, 354, 374 n.102, 387 (2000) [hereinafter Frischmann, *Innovation*]; William Fisher, *Intellectual Property and Innovation: Theoretical, Empirical, and Historical Perspectives*, 37 Industrial Property, Innovation, and the Knowledge-based Economy, Beleidsstudies Technologie Economie, 2–3 (on-line version 2001), cyber.law.harvard.edu/people/tfisher/Innovation.pdf.

[85] *See* Joseph E. Stiglitz, *Lecture, Economic Foundations of Intellectual Property Rights*, 57 Duke L. J. 1693, 1722 (2008) (employing a different, three-part classification – patents, prizes, and government-funded research – and focusing on six attributes of these choices: selection of research targets; financing methods; dissemination incentives; nature of the risks; innovation incentives; and transaction costs).

[86] *See* Organization for Economic Cooperation and Development, *National Systems for Financing Innovation*, 11–12 (1995).

[87] *See* Frischmann, *Innovation*, *supra* note 84, at 387.

[88] *See id.* at 352–3; Henrik Kristensen et al., *Adopting Eco-Innovation in Danish Polymer Industry Working with Nanotechnology: Drivers, Barriers and Future Strategies*, 6 Nanotech. L. & Bus. 416, 433 (2009). *See also* Frischmann, *Innovation*, *supra* note 84, at 392.

[89] Keith Maskus, *Research and Development Subsidies: A Need for WTO Disciplines?* E15 Initiative, International Centre for Trade and Sustainable Development (ICTSD) and World Economic Forum (2015), http://e15initiative.org/wp-content/uploads/2015/01/E15_Subsidies_Maskus_final.pdf.

innovation development to such firms, which often is (debatably) argued to be better than having the government direct which innovations to target.[90]

But such simple insights do not get us very far because other forms of subsidies are available that could potentially induce more effective and efficient R&D and innovation development in the private sector. Such alternative subsidies include funds provided to universities and nonprofit research centers, or development through resources provided by private foundations. There are simply too many potentially effective alternative subsidy mechanisms to choose from[91] with too little analysis of the relative institutional competencies of the various actors, including government bureaucrats and the decision-making processes that they follow.[92] Different kinds of subsidies are illustrated by many of the other chapters in this book discussing the operation of PPPs in the global health sector.[93]

2 Procurement

Procurement resembles R&D innovation subsidies, but it typically provides incentives by conditioning funding on achieving innovation outputs that are commercial or noncommercial products. Although there is no theoretically necessary relationship between government procurement and the creation of IP rights, the US Bayh-Dole Act (under which private recipients of government funding may acquire patent title to inventions developed with that funding) applies to US Government procurement contracts 'for the performance of experimental, developmental, or research work funded in whole or in part by the Federal Government' as well as to grants.[94]

The effects of procurement on innovation depend partly on whether the contracts take the form of 'push' or 'pull' mechanisms with regard to existing or future markets. Push mechanisms (*ex ante* market procurement) provide a demonstration of technology and a stimulus to market development so that industry may subsequently be more willing to risk market entry.[95] Push mechanisms raise questions as to the size of the government sector and its adequacy to demonstrate commercial viability in a broader market without government subsidies to production or consumption. Regulation of market prices for innovation outputs (or rate-based returns to regulated industries, as in the electric utility sector) further complicates the evaluation of the inducement effectiveness and adequacy of innovation returns to procurement funding.[96]

Pull mechanisms (*ex post* market procurement) provide *ex ante* innovation incentives based on assurances of *ex post* (relative to the time of creating innovations) procurement

[90] *See* Frischmann, *Innovation*, *supra* note 84, at 352–53.
[91] *Id.* at 392–95.
[92] *See* Tomain at 404–16; Mark Radka, *Some Perspectives About the Climate Technology Centre/Climate Technology Network*, U.N. Environment Programme 101 (2012), http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/some_perspectives_about_the_ctc_ctn.pdf.
[93] See chapters in this book by Frederick M. Abbott, chapter 2, *supra*; Anatole Krattiger et al., chapter 3, *supra*; Katy M. Graef et al., chapter 4, *supra*; Esteban Burrone, chapter 5, *supra*; Hilde Stevens et al., chapter 6, *supra*.
[94] Patent Rights in Inventions Made With Federal Assistance: Definitions, 35 U.S.C. §201(b) (2006).
[95] *See, e.g.*, Vernon W. Ruttan, Is War Necessary for Economic Growth? Military Procurement and Technology Development 108–09 (2006).
[96] *See, e.g.*, Paul L. Joskow & Nancy L. Rose, *The Effects of Economic Regulation*, *in* Handbook of Industrial Organization 1464–77 (1989); C.O. Ruggles, *Problems of Public-Utility Rate Regulation and Fair Return*, 32 J. Pol. Econ. 543, 543–58 (1924).

funding and adequacy of scale for commercialization, which again reduces market entry risks. These *ex post* assurances of procurement (such as advanced purchase commitment contracts) are, effectively, *ex post* innovation consumption subsidies, where the government acts as a consumer on behalf of itself or of the general public. However, the price terms of these *ex post* innovation contracts may be highly uncertain. They also may be subject to statutory and 'march-in' rights regarding patented innovation outputs and to other contractually retained rights of the government or PPP procuring entity. Often in PPPs, the scope of the market purchase guarantees, conditions on market behavior, pricing terms and treatment of developed (foreground) IP, and retained ownership rights are negotiated in advance.[97]

Examples of procurement strategies by PPPs abound in the global health area, for example, the GAVI and other PPPs that work with advance commitments.[98]

3 Direct Development

Governments directly engage in all sorts of R&D and innovation development, funded through general or specific taxes and other sources of revenue. This reflects that government employees are user-innovators, that government agencies engage in R&D to generate different kinds of innovation outputs in the course of conducting their statutory mandates, and that government sometimes creates specialized bureaucracies to perform R&D and to generate innovation in particular sectors. The most well-known of these specialized R&D bureaucracies are the national laboratories.

US government policy permits cooperative R&D agreements (CRADAs) with private entities.[99] This allows for greater leveraging of federal funding for particular forms of innovation conducted within the government. Further, private entities may manage government research bureaucracies, such as the National Renewable Energy Laboratory (NREL) of the US Department of Energy – originally, the Solar Energy Research Institute – thereby blurring the line between the public and private sectors.[100] Additionally, government can collaborate among its own agencies,[101] with subsidiary or foreign governments, or with INGOs through interpersonnel agreements[102] and other collaborative efforts and personnel exchanges.[103] Government also can engage in collaborative R&D efforts, thereby pooling funds, technology, and other resources like in joint-venturing.

[97] *See* Ron Bouchard, *Qualifying Intellectual Property II: A New Innovation Index for Pharmaceutical Patents & Products*, 28 Santa Clara Comp. & High Tech. L.J. 287, 382 (2011).
[98] *See* Frederick M. Abbott, chapter 2, *supra*.
[99] *See* Federal Technology Transfer Act, 15 U.S.C. 3710 §12(d)(1) (1986); Matthew Rimmer, Intellectual Property and Climate Change: Inventing Clean Technologies 276–77 (2001).
[100] *See, e.g.*, National Renewable Energy Laboratory, Batelle, www.battelle.org/our-work/laboratory-management/national-renewable-energy-laboratory.
[101] *See, e.g.*, OMB 2013 Budget Report, at 369 (Apr. 29, 2013).
[102] *See, e.g.*, Intergovernmental Personnel Act of 1970, Pub. L. No. 91–648, 84 Stat. 1909 (1971) (codified as amended at 42 U.S.C. §4701 et seq. (2006)).
[103] *See, e.g.*, US Department of State, Memorandum of Understanding to Enhance Cooperation on Climate Change, Energy and Environment Between the Government of the United States of America and the Government of the People's Republic of China (Jul. 2009), https://2009–2017.state.gov/r/pa/prs/ps/2009/july/126592.htm; US Department of State, Memorandum of Understanding Signed Between the Government of India and the Government of the United States, (Nov. 30, 2009), https://2009–2017.state.gov/p/sca/rls/press/2009/132776.htm.

Government direct development thus may lead to the generation of government-owned IP rights. For example, NREL possesses a significant portfolio of patents on wind turbines, generators, power systems, cooling towers, biofuels, and geothermal technologies and building construction. NREL has also developed an online database – the Energy Efficiency and Renewable Energy Technology Portal – to license its rights.[104] Depending on how they are exercised, these government-owned IP rights may have further effects on domestic and foreign markets and trade flows.[105] Whether and how the government chooses to license its IP rights for further R&D or innovation then becomes an important issue, as the government may choose to compete with the private sector in the market (although it rarely does). Even if the government does not directly compete with the private sector and supplies only to the government sector, government development and supply can lead to price reductions in the commercial market through competitive development. Furthermore, government direct development may impact private market shares that would be smaller without the inclusion of the government sector, allowing private entities to better recoup their innovation investments.

4 Constructed Commons

Yet another form of government innovation funding relates to the creation of various kinds of commons for managing physical or information resources to induce innovation.[106] The most obvious form of commons is government-created or government-subsidized physical infrastructure, such as the highway system or the Internet.[107] But commons in information also may be constructed, subsidized, or regulated by government. For example, the World Meteorological Organization – a United Nations specialized agency – and others sponsor and make available data on polar climate conditions that are generated and submitted by both governments and private sector scientists.[108] Another example, the Conservation Commons, is a cooperative effort of INGOs, non-governmental organizations, governments, academic institutions, and entities from the private sector. The Conservation Commons supports open access to data and sharing (with attribution) of information regarding biodiversity.[109] The US Government's Global Positioning Satellite (GPS) signals are freely available from the military and NASA, following an international incident after which NASA concluded that the public

[104] Rimmer, *supra* note 99, at 290–91.

[105] *Id.* at 266 (citing Daniel Roth, *The Radical Pragmatist*, WIRED, 104, 108 (2010)).

[106] *See* Michael W. Carroll, *Copyright, Fair Use, and Creative Commons Licenses, in Risk and Entrepreneurship in* LIBRARIES: SEIZING OPPORTUNITIES FOR CHANGE 18 (Pamela Bluh & Cindy Hepfer eds., 2009); Madison, Frischmann, & Strandburg, *supra* note 84, at 681–82.

[107] *See* Brett M. Frischmann, INFRASTUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES 5–6 (2012); Brett M. Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 MINN. L. REV. 917, 923–24, 956 (2005) [hereinafter cited as Frischmann, *An Economic Theory*]; Gregory N. Mandel, *When to Open Infrastructure Access*, 35 ECOLOGY L. Q. 205, 208–10 (2008); Konstantinos Styianou, *An Innovation-Centric Approach of Telecommunications Infrastructure Regulation*, 16 VA. J.L. & TECH. 221, 231–40 (2011).

[108] *See* Welcome to the Polar Information Commons (PIC), POLAR INFORMATION COMMONS, www.polarcommons.org/.

[109] *See, e.g.*, *Conservation Commons*, CONSERVEONLINE, http://conserveonline.org/workspaces/commons/.

benefits of new, nonmilitary, and nonaviation uses of the data justified continuing to provide it free of cost.[110]

Governments also may subsidize and regulate private sector commons institutions regarding prices of inputs and outputs, access and other terms of interaction, and may choose to limit the application of competition law and policy to facilitate commons development.[111] Similar to government direct development, government-commons approaches may supplement or compete with the private sector with regard to innovation promotion. For example, governments may affect commons-based activities by requiring or encouraging the pooling of technology or IP rights;[112] providing or supporting free or low-cost access to information outputs that are R&D or innovation inputs;[113] and engaging in or encouraging interpersonal exchanges.[114] If technology- or patent-pooling occurs, significant competition regulation issues will arise.

Similarly, public-sourced or public-sponsored commons may compete with private efforts to create commons, whether through the creation of technology or IP pools or databases, or through the encouragement of liberal licensing policies.[115] However, government-constructed and government-managed commons do not normally or purposefully compete with private R&D or innovation activity in research or production markets, even if they generate information outputs that are inputs to further R&D or innovation. Rather, such public commons typically seek to facilitate public or private R&D and innovation by lowering investment costs through creating infrastructure or other forms of commons resources, and by pooling expertise and information that otherwise might not as readily be compiled. Such public commons thus typically supplement other forms of government sponsorship of public and private R&D and innovation, rather than substitute for them. Longtime expert observers have recently proposed such a data commons and an IP pledging community for solar climate engineering research and technological developments.[116]

110 *See* James Love & Tim Hubbard, *Paying for Public Goods*, *in* Code: Collaborative Ownership and the Digital Economy 207, 208–09 (James Love, Tim Hubbard, & Rishab Aiyer Ghosh eds., 2005).

111 *See, e.g.*, C. Scott Hemphill, *Network Neutrality and the False Promise of Zero-Price Regulation*, 25 Yale J. Reg. 135, 164–75 (2008); Michael Madison, Brett M. Frischmann, & Katherine Strandburg, *The University as Constructed Cultural Commons*, 30 Wash. U. J. L. & Pol'y 365, 375–76 (2009). *See generally* Lawrence Lessig, Code: Version 2.0 (2006).

112 *See* Dustin Szakalski, *Progress in the Aircraft Industry and the Role of Patent Pools and Cross-Licensing Agreements*, 15 UCLA J. L. & Tech. 1 (2011); Harry Dykman, *Patent Licensing Within the Manufacturer's Aircraft Association (MAA)*, 46 J. Pat. & Trademark Off. Soc'y 646 (1964); Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 Colum. L. Rev. 839, 888–90 (1990).

113 *See, e.g.*, US Department Energy Off. Sci., Human Genome Project Information (2011), www.ornl.gov/sci/techresources/Human_Genome/home.shtml; International HapMap Project (2011), http://hapmap.ncbi.nlm.nih.gov; Technology Mechanism, UNFCCC (2013), http://unfccc.int/ttclear/templates/render_cms_page?TEM_home.

114 *See, e.g.*, US Dept. of Energy, DOE/NNSA Overseas Presence Advisory Board's Overseas Corps Training Program Agreement, http://energy.gov/sites/prod/files/DOE-Overseas-Corps-Training-Program.pdf.

115 *See* Green Exchange (2012), http://www.greenexchange.com; Wayne Balta, *Welcome to the Eco-Patent Commons*, CEF EcoInnovator Blog, www.corporateecoforum.com/welcome-to-the-eco-patent-commons/; *Welcome to PLOS*, Public Library of Science, www.plos.org; *Creative Commons*, Science, https://creativecommons.org/about/program-areas/open-science; R. Kunstadt & I. Maggioni, A *Proposed "U.S. Public Patent Pool,"* Les Nouvelles, 10–13 (2011).

116 Reynolds, Contreras, & Sarnoff, *supra* note *.

5 Market Regulation

The fifth and final mechanism of government innovation funding is market regulation, which is also a very broad category. Regulation covers: (a) direct product and process regulation; (b) information reporting and government disclosures, which may also lead to (or induce private action to avoid) direct product and process regulation;[117] (c) recognition and certification programs,[118] the premises of which are to provide incentives to direct private actions and to convey a market advantage that induces directed consumption patterns and thus greater innovation;[119] and (d) a wide variety of market-structure and market-operation regulations, including market-entry, price, competition, and IP rights regulations. All of these may affect innovation incentives by governing market-based returns of PPPs. Of these various forms of market regulation, this section focuses on IP and antitrust (competition) laws. It contextualizes the innovation policy choices within larger debates about the global IP legal regime and related global governance of climate change technologies.

In considering direct regulation by governments of market structures and operations, both IP and competition laws are the most obvious places to look (although price controls, crown use, statutory and compulsory licensing, and other forms of regulation of private market returns relating to technological products and services also may be used).[120] IP rights may be viewed as a form of market regulation, although they also provide a government subsidy (a property right), given that the exclusive right regulates market behaviors through government regulatory clearances and litigation mechanisms (which can include actions brought by the government).[121] Further, even when viewed as subsidies, IP rights are subject to IP and competition law doctrines that regulate how such rights relate to and are used in markets, whether such rights are considered to be property rights or to be regulatory rights, or a combination of both.[122]

The optimal strength, scope, and duration of IP rights that governments may grant depend on multiple, competing considerations. These include the following eight concerns: (a) private reliance on IP rights as a means of recouping investments in innovation, combined with government market regulation of the returns on such investments;[123]

117 *See* Wesley A. Magat & W. Kip Viscusi, Informational Approaches to Regulation 4–5 (1992).

118 *See, e.g.*, U.S. EPA, Climate Leadership Awards, www.epa.gov/climateleadership/awards/index.html; Margaret Chon, *Trademark Goodwill as a Public Good: Brands and Innovations in Corporate Social Responsibility*, 21 Lewis & Clark L. Rev. 277 (2017).

119 *See, e.g.*, U.S. EPA, Energy Star® – The Power to Protect the Environment Through Energy Efficiency, EPA 430-R-03–008, 2–3 (2003).

120 *See, e.g.*, Lionel Nesta, Francesco Vona, & Francesco Nicolli, *Environmental Policies, Product Market Regulation and Innovation in Renewable Energy* (2012) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2192441. *See generally*, B. Zorina Khan, *Antitrust and Innovation Before the Sherman Act*, 77 Antitrust L.J. 757, 759–60, 784–5 (2011).

121 *See, e.g.*, Criminal Offenses, 17 U.S.C. §506(a) (2006); Criminal Infringement of a Copyright, 18 U.S.C. §2319(a) (2006).

122 *See, e.g.*, Oil States Energy Servs., LLC v. Greene's Energy Group, LLC, 138 S.Ct. 1365 (2018) (holding that patents are "public franchises" even if they are private property, and thus fall under the "public rights" doctrine).

123 *See generally* Cohen et al., *supra* note 3, at 2; Wesley M. Cohen & Richard C. Levin, *Empirical Studies of Innovation and Market Structure*, in 2 Handbook of Industrial Organization 1059 (Richard Schmalensee & Robert Willig eds., 1989); Wesley M. Cohen et al., *Firm Size & R&D Intensity: A Re-Examination*, 35 J. Industrial Econ. 543, 548–49 (1987).

(b) public funding of inputs to private research and development; (c) values of private researchers (or their firms) regarding the public's interests; (d) the pioneering or cumulative nature of the research; (e) the degree of centralization of firm structures; (f) dependence on IP for funding of R&D or firm ventures; (g) documentation and publication practices that make it harder to build on others' work or to avoid infringement or clear rights; and (h) various types of network externalities.[124] Unfortunately, economic and theoretical analyses of direct measures to restrict static social welfare losses of granting property rights in intellectual productions, and of efforts to balance those losses against dynamic innovation-incentive losses – such as price controls or compulsory licensing – have proven theoretically intractable.[125] As remains true more than a decade after it was said, '[e]fforts to identify an optimal balance of these various effects continue, but no solution is yet in sight'.[126]

Antitrust analyses reflect similar theoretical and empirical limitations. Much has been written about differences of innovation and product markets and the need to differentiate antitrust and IP doctrines as a result of different market structures and dynamics for different products and timeframes.[127] Innovation market concerns reflect the insight 'that a merger between the only two, or two of a few, firms in R&D might increase the incentive to suppress at least one of the research paths.'[128] As a recent criticism of even a limited discussion of innovation markets has stated, the 'fundamental flaws in the innovation market concept are . . . [that we] don't know about the relationship between market structure and effect, that error costs are high, and that competition is multidimensional. In other words, we don't know a lot and acting on our ignorance . . . is costly.'[129]

As stated earlier, many people and institutions have recognized the unequal technology transfer framework for climate change and energy innovation. To address these concerns, numerous changes, some highly controversial, have been proposed to the global patent regime.[130] These include: broad, categorical exclusions of environmentally sound or climate friendly technologies from the patent system; and regulation of licensing and market behaviors, including compulsory licensing, antitrust scrutiny, and price controls.[131] These direct means of regulating prices and competition will remain legally

[124] *See* Fisher, *supra* note 84, at 17–18, 24–25.

[125] *See, e.g.*, Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, Winter 1991 J. Econ. Persp. 33–35 (2009); Rudolph J. R. Peritz, *Competition Within Intellectual Property Regimes: The Instance of Patent Rights*, *in* Intellectual Property and Competition Law: New Frontiers 27 (Steven Anderman & Ariel Ezrachi eds., 2011).

[126] Fisher, *supra* note 124, at 9.

[127] *See, e.g.*, Janusz A. Ordover, *Economic Foundations and Considerations in Protecting Industrial and Intellectual Property*, 53 Antitrust L. J. 503, 514–18 (1984); J. Thomas Rosch, *Antitrust Regulation of Innovation Markets: Remarks at the ABA Antitrust Intellectual Property Conference*, (2009). *See generally* Jonathan Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes*, 119 Yale L. J. 384 (2009); Mark Lemley, *Industry-Specific Antitrust Policy for Innovation*, 2011 Colum. Bus. L. Rev. 637 (2011).

[128] Michael A. Carrier, Innovation for the 21st Century: Harnessing the Power of Intellectual Property and Antitrust Law 297 (2009).

[129] Geoffrey Manne, *Assuming More Than We Know About Innovation Markets: A Review of Michael Carrier's Innovation in the 21st Century*, 61 Ala. L. Rev. 553, 555 (2010). *But cf.* Michael Carrier, *Innovation for the 21st Century: A Response to Seven Critics*, 61 Ala. L. Rev. 597, 601–3 (2010).

[130] Abdel-Latif, et al., *supra* note 29.

[131] *See, e.g.*, K. Ravi Srinivas, *Climate Change, Technology Transfer and Intellectual Property Rights, Research and Information System for Developing Countries*, Discussion Paper No. 153, 26–7 (2009),

available to governments that hope to induce – but may be forced to compel – more favorable licensing and pricing practices than would voluntarily occur.[132]

Although further amendment of the WTO Agreement on Trade Related Aspects of Intellectual Property (TRIPS Agreement) – as has been discussed by the United Nations Secretariat[133] – is a theoretical possibility, consensus for adopting amendments in the short term is highly unlikely. Without such treaty amendments, countries (particularly those in the developing South) may seek to make greater use of existing TRIPS Agreement flexibilities to tailor their patent doctrines to assure access and to lower costs. They may adopt exclusions from patent eligibility, exceptions to patent rights, and alternatives to private licensing (such as a global technology pool). They also may expand access to publicly funded technologies to better promote technology development, transfer, and use.[134] These options may provide greater *ex ante* predictability "in accessing technologies and [may] further enable much-needed research and development for local adaptation and dissemination, which would further reduce the cost of the technologies."[135]

Governments addressing private refusals to license patented technologies or high prices for access to those technologies may regulate such conduct directly, by adopting compulsory licenses or by imposing price control regulations.[136] Alternatively, they may regulate such conduct indirectly, by treating restrictive or costly licensing as a competition violation (for example, as an abuse of dominant position) or by treating the patents themselves as essential facilities (that is, as products or services that are considered competitive necessities and for which access also can be required by compulsory licenses).[137]

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1440742; Jerome H. Reichman, *Intellectual Property in International Perspective: Institute for Intellectual Property & Information Law Symposium*, 48 Hous. L. Rev. 1137–8 (2009) [hereinafter Reichman, *International Perspectives*]; Peter Lee, *Toward a Distributive Commons in Patent Law*, 2009 Wis. L. Rev. 974–6 (2009); Estelle Derclaye, *Not Only Innovation But Also Collaboration, Funding, Goodwill and Commitment: Which Role for Patent Laws in Post-Copenhagen Climate Change Action*, 9 J. Marshall Rev. Intell. Prop. L. 663 (2010).

132 Concerns over IP rights and climate change technologies have already caused significant political tensions. At an earlier stage of international negotiations, the UNFCCC Ad Hoc Working Group on Long-term Cooperative Action (WG-LCA) considered various proposals that had been suggested by some countries in the South. These measures would have placed significant restrictions on the traditional operation of the patent system. The measures ranged from requiring patent pooling and royalty free compulsory licensing to excluding green technologies entirely from patenting – even retroactively revoking existing patent rights. *See, e.g.*, *Ad Hoc Working Group on Long-Term Cooperative Action Under the Convention, Ideas and proposals on the elements contained in paragraph 1 of the Bali Action Plan*, 23 UNFCCC (2009); Ad Hoc Working Group on Long-Term Cooperative Action Under the Convention, Report of the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention on its Seventh Session, UNFCCC Doc. No. FCCC/AWGLCA/2009/14, 156 (2009).

133 Agreement on Trade-Related Aspects of Intellectual Property Rights (April 15, 1994), Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, Legal Instruments – Result of the Uruguay Rounds 33 I.L.M. 81 (1994) [hereinafter TRIPS Agreement]. *See, e.g.*, *World Economic and Social Survey 2009*, U. N. Dept. of Econ. and Soc. Affairs 133–34 (2009).

134 *See World Economic and Social Survey 2010*, U. N. Dept. of Econ. and Soc. Affairs 97 (2010).

135 *Id.*

136 *See, e.g.*, Keith E. Maskus, *The Curious Economics of Parallel Imports*, 2 W.I.P.O. J. 123–4 (2010) [hereinafter Maskus, *Parallel Imports*].

137 *See, e.g.*, Jay P. Choi, *Compulsory Licensing as an Antitrust Remedy*, 2 W.I.P.O. J. 74, 74–77 (2010). European Commission Dec. of 13 May 2009, COMP/37.990 (Intel) ¶¶ 1749–53, http://ec.europa.eu/competition/antitrust/cases/dec_docs/37990/37990_3581_11.pdf. *But see Verizon v. Trinko*, 540 U.S. 398, 407–08 (2004).

Such direct or indirect regulation, moreover, may be largely ineffective in regard to assuring transfers of tacit knowledge.[138]

Both direct and indirect approaches to regulating access and prices will be highly controversial, and may threaten substantial trade retaliation or may prompt withholding by businesses of technology and foreign investment. Compulsory licensing, price regulation, and antitrust treatment have been repeatedly resisted by the United States and (somewhat less so) by other developed countries, particularly in foreign markets where the countries do not bear the costs but reap the benefits of technology exports.[139] The developing South may be unwilling to resist such trade pressures, even if the threats and trade sanctions would be found illegal under WTO rules.[140] These legal and political constraints bring us to proposals discussed in the next Part of this chapter, which emphasize private sector, voluntary initiatives to increase access and technology transfer, within a context of public sector laws and policies that promote innovation and access.

III Key Innovation Policy Choices in Climate Change Technology Transfer

In contrast to the comparative advantages that would lead to further extending the developed North's innovation and patenting head start, international action on climate change may help to narrow the gap either through cooperative trade measures like trade-tariff exemptions or through cooperative technology development efforts, such as multinational joint ventures or joint manufacturing for particular climate change technologies.[141] Similarly, international efforts may transfer technology directly to developing countries, through foreign-funded, in-country R&D, through joint ventures, and through foreign direct investment in R&D.[142] However, many obstacles exist to such foreign-funded or participatory R&D efforts that rely principally on market-based approaches – including significant fears of loss of control over technologies protected by patents and trade secrets, given the perceived lack of adequate enforcement of patent and trade secret rights in developing countries.[143] This Part first discusses some of the challenges to technology transfer given the global imbalances discussed in Part I and additional concerns specific to climate change technology transfer, then proposes six innovation policy choices that could help to mobilize R&D and to transfer technology more effectively.

[138] *See, e.g.*, Jerome H. Reichman, *Comment: Compulsory Licensing of Patented Pharmaceutical Inventions: Evaluating the Options*, 37 J.L. Med. & Ethics 253–57 (2009).

[139] *Cf. id.* at 255.

[140] *See, e.g.*, *id.* at 258–59.

[141] *See, e.g.*, Lee, Iliev, & Preston, *supra* note 62, at xi; UNEP/EPO/ICTSD Study, *supra* note 62, at 21–23; Robert Fair, *Does Climate Change Justify Compulsory Licensing of Green Technology*, 6 B.Y.U. Int'l L. & Mgmt. Rev. 21, 40–41 (2009).

[142] *See, e.g.*, Lee, Iliev, & Preston, *supra* note 62, at ix-x, 58; Elizabeth Burleson, *Energy Policy, Intellecutal Property, and Technology Transfer to Address Climate Change*, 18 Transnat'l L. & Contemp. Probs. 69, 86 (2009).

[143] *See, e.g.*, Lee, Iliev & Preston, *supra* note 62, at 8; Daniel Johnson & Kristina Lybecker, *Challenges to Technology Transfer: A Literature Review of the Constraints on Environmental Technology Dissemination* (2009). *See generally* Peter K. Yu, *Enforcement, Economics and Estimates*, 2 W.I.P.O. J. 1 (2010).

A *Geographic Imbalances in Technology Transfer to, and Costs of Access in, the Developing South*

Technology transfer typically occurs through trade, foreign direct investment (FDI), joint venturing, or licensing.[144] Although some studies suggest that licensing and FDI (and consequently technology transfers) are positively correlated with stronger IP rights,[145] other studies specific to climate change technologies demonstrate that so far these technologies have not been widely licensed to developing countries (even to those having competitive markets). This may be due to IP ownership over those technologies in the developed North or to other factors, such as the lack of scientific capability, adverse market conditions, and poor investment climates in the developing South.[146] Although some studies have concluded that North–South licensing for climate change-related technologies are no lower than for other technologies (while desires to transfer climate change-related technologies are higher),[147] other studies have concluded that climate change mitigation technologies "are less likely to cross country borders than the average technology," are principally transferred among developed countries, and "seem to crowd out local innovations."[148]

Technology flows thus occur principally among developed countries (about seventy-five percent of exported inventions) and are "almost non-existent" between emerging countries.[149] The general pattern of low levels of technology transfer from the developed to the developing world is likely to remain stable for climate change technologies. Given reliance on private markets and IP rights, these general patterns may skew even more strongly against flows to and among developing countries, notwithstanding funding from international agreements that could potentially change these patterns.

Moreover, the development and/or patenting of climate change technologies within developing countries remains low. For example, one study finds that "less than 1% of the world's clean energy technology related patent applications from 1980 to 2009 have been filed in Africa."[150] As noted in another study, the surveyed data "all suggest that companies from developing countries are facing some difficulties in obtaining technologies, whether it is the high cost of licensing or having to obtain technologies from second-tier technology holders," that is, from companies other than leading manufacturers (who are reluctant to license potential competitors).[151] To enhance the dissemination of

144 *See* Hall & Helmers, *supra* note 14, at 7.

145 *See, e.g., id.* at 11; Lee Branstetter et al., *Has the Shift to Stronger Intellectual Property Rights Promoted Technology Transfer, FDI, and Industrial Development?*, 2 W.I.P.O. J. 93, 96–98 (2010).

146 *See, e.g.*, UNEP/EPO/ICTSD Study, *supra* note 62, at 58; Kaitlin Mara, *New Climate Technologies Rarely Reaching Developing Countries, Panel Says*, IP Watch (Jul. 13, 2010).

147 *See, e.g.*, UNEP/EPO/ICTSD Study, *supra* note 62, at 9, 58–59.

148 Dechezleprêtre 2008a, *supra* note 62, at 25.

149 *See id.* at 4.

150 EPO-UNEP, *Patents and Clean Energy Technologies in Africa*, Eur. Pat. Off., www.epo.org/news-issues/technology/sustainable-technologies/clean-energy/patents-africa.html. The EPO has also a study on Latin America reaching relatively similar conclusions. *See Overview of the Latin American and Caribbean Clean Energy Potential and Exploitation Levels*, Eur. Pat. Off., http://documents.epo.org/projects/babylon/eponet.nsf/0/2841b369787d5e72c1257da800335111/$FILE/patents_Latin_America_summary_en.pdf.

151 UNEP/EPO/ICTSD Study, *supra* note 62, at 22–23.

climate change-related technologies, developing nations are under pressure to reduce tariffs. But such countries also may have been pressured to patent new technologies. This may impose a "double penalty" of foreign competition on local technology development (by lower import tariffs and domestic patenting of foreign technologies) that might otherwise proceed at lower costs through (unpatented) imitation.[152] In contrast, local imitation may sometimes be difficult or may require significant adaptation to local conditions.[153]

Developing countries, as well as developed countries and international agencies funding such technology deployment and dissemination, may therefore be more likely to challenge patent rights that prevent lower-cost production and acquisition of such technologies. In turn, this raises the possibility of disputes under the TRIPS Agreement[154] and under international investment protection agreements.[155] Alternatively, climate change technology-rich countries may adopt explicit or implicit export subsidies to facilitate technology transfers, which may generate additional trade disputes.[156]

The global imbalances in patenting noted earlier thus are also reflected in global imbalances in licensing and technology transfers from the developed North to the developing South. Even without regard to the dramatic geographical imbalances in patenting and licensing behaviors, patented climate change technologies so far have taken very long times to reach the mass market and to achieve widespread dissemination.[157] As the recent effort to achieve a worldwide cell-phone standard has also demonstrated, patent rights may delay or interfere with coordinated approaches to achieve worldwide technology development and deployment.[158] When technology has been developed through R&D subsidies and transferred at low cost to developing countries, its use still may require additional subsidies to overcome the sunk costs of existing infrastructure or equipment, and local adaptation (or invention) may be needed to provide sufficient comparative benefits to actual users, given that the technology needs in developing countries may differ from those in developed countries.[159] Thus, relying on private markets and patents to distribute the needed technologies to the South may prove both costly and less than optimally effective.

[152] Keith E. Maskus, *Intellectual Property and the Transfer of Green Technologies: An Essay on Economic Perspectives*, 1 W.I.P.O. J. 133, 137 (2009).

[153] *See* Eur. Pat. Off., *supra* note 150, at 17.

[154] TRIPS Agreement, *supra* note 133.

[155] *See, e.g.*, Canada NAFTA Decision, Case No. UNCT/14/2, final award, (Mar. 16, 2017), www.ippractice.ca/blog/wp-content/uploads/2017/03/Lilly-v-Canada-NAFTA-Arb-Award.pdf. *See generally* Hall & Helmers, *supra* note 14; Ad Hoc Working Group on Long-Term Cooperative Action Under the Convention Report of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention on its Seventh Session, U.N. Doc. FCCC/AWGLCA/2009/14, at 156 (Nov. 20, 2009). *See generally* Lahra Liberti, *Intellectual Property Rights in International Investment Agreements* (OECD, Working Paper No. 2010/01, 2010); Bertram Boie, *The Protection of Intellectual Property Rights through Bilateral Investment Treaties: Is there a TRIPS-plus Dimension?* (NCRR Trade Regulation, Working Paper No. 2010/19, Nov. 2010).

[156] *See, e.g.*, Thomas L. Brewer, *The Trade Regime and the Climate Regime: Institutional Evolution and Adaptation*, 3 Climate Pol'y 329, 338 (2003).

[157] *See* Lee, Iliev, & Preston, *supra* note 62, at vii; World Development Report 2010, *supra* note 45, at 293.

[158] *See, e.g.*, Branislav Hazucha, International Standards and Essential Patents: From International Harmonization to Competition of Technologies, 27, 30 (2010).

[159] *See* Hall & Helmers, *supra* note 14, at 4–6.

B *Innovation Policy Choices to Enhance Access and to Reduce Costs of Intellectual Property Rights in Climate Change Technologies*

Some of the proposed innovation policy choices discussed in this section are public sector-based, some are private sector-based ownership controls,[160] and some are a combination of both. The first set of approaches focus on public sector laws and policies, seeking to expand freedom-to-innovate and to develop local innovation capacity and indigenous R&D within particular jurisdictions. They would do so by restricting the definition of what can be patented and by authorizing certain experimental and other uses of climate change-related technologies, so as to promote greater sequential innovation and to assure functionality and development or regulatory information. The second set of approaches focus on the private sector policies and choices (although they are applicable to the public sector and PPP choices when acting as proprietors rather than as regulators). They seek to leverage ownership powers to require licensing innovation choices that better assure access to climate change-related technologies at reasonable costs. The final set of approaches again focus principally on the public sector, and seek to clarify when it will regulate private licensing of inventions deriving from government subsidies and to better assure that climate change-related technology can be transferred within the private sector from one jurisdiction to another.

These alternatives focus on achieving the greatest benefits for climate change innovation, in both the developed and developing world, in ways generally recognized as consistent with existing international IP treaty laws. They thus promise a greater likelihood of being employed to develop the needed technologies, compared to more politically intractable treaty revisions, while controlling the costs of access and better assuring transfer of the needed technologies.[161]

1 Protecting Basic Research and Sequential Innovation

The first set of innovation policy choices focuses on protecting basic research and sequential innovation and use of technologies through governmental patent laws and policies. The first measure would assure that significant additional creativity beyond basic scientific discovery is needed for patent eligibility.[162] This approach is based on adopting

[160] *See, e.g.*, Colleen V. Chien, *Opening Up The Patent System: Exclusionary And Diffusionary Levers In Patent Law*, 89 So. Calif. L. Rev. 793, 801, 820 (2016) (defining "Defensive patenting – holding patents in order to facilitate freedom to operate – is practiced by an estimated half or more of patent holders" and stating further that "[w]hile it often seems that there are only two approaches for supporting innovation with patents – to opt-in and exclude, or to opt-out and share, intellectual property, a widely-used approach between them is to acquire patents in order to share, or "defensive patenting. . . . It is widely recognized that different industries use patents differently, and that patents support a diversity of business models. Allowing innovators to individually tailor patent rights, and in some cases, to change these options over the lifetime of the patent, would provide precise controls to those in the best position to know the optimal balance between exclusion and diffusion with respect to a particular invention."). *See generally* van Overwalle, *supra* note 22.

[161] Dominique Foray, *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies*, 38 (2009); Oliva, et al., *supra* note 15, at 5–7; Maskus & Okediji, *Intellectual Property Rights*, *supra* note 15, at vii–viii, 26–7.

[162] *See* Joshua D. Sarnoff, *Patent Eligible Inventions after Bilski: History and Theory*, *supra* note *; Peter Lee, *Inverting the Logic of Scientific Discovery: Applying Common Law Patentable Subject Matter Doctrine to Constrain Patents on Biotechnology Research Tools*, 19 Harv. J.L. & Tech, 84 (2005).

a restrictive interpretation of the meaning of "invention" as used in Article 27.1 of the TRIPS Agreement.[163] The second measure assumes that relevant climate change technologies exist under patent in a jurisdiction, and would encourage and (where needed) expand robust legal exceptions to infringement liability for experimental uses, reverse engineering, development of information for pre-market approval, and inter-operability. This would permit scientific research and continued access to important technologies to proceed unfettered by patent rights.[164] These proposed measures remain consistent with the permissive language for mandatory coverage of patents under Article 27.1 of the TRIPS Agreement, as well as for exceptions and limitations to rights under Article 30 of the TRIPS Agreement.[165] They also would help to allow scientific knowledge to flow to the developing South, and to permit downstream development and use of the creative technologies that result, just as dependent patent licenses and "government use compulsory licenses"[166] may sometimes be needed to assure the ability to operate, market access and reasonable-cost technology transfer.

2 Expanding Ownership Controls over Downstream Licensing Mechanisms

The next two sets of innovation policy choices are particularly salient to PPPs because they would originate principally from the private sector, although similar actions could be taken by governments or PPPs when acting as proprietary owners of the relevant IP. The purpose of these proposals would be to seek to assure that upstream owners of patented climate change technologies retain various rights when licensing for commercial development, so as to assure the potential for continued R&D and for widespread and low-cost access. As Keith Maskus and Ruth Okediji have noted, contractual arrangements "govern the majority of inter-firm and intra-firm transfers of knowledge and technology in both domestic and international markets."[167] Thus these approaches exert management-based (or private, market-driven) policy choices of innovation via ownership controls.[168]

[163] *See* TRIPS Agreement, *supra* note 133, Art. 27.1.

[164] *See, e.g.*, 35 U.S.C. § 271(e); *Merck KGAA v. Integra LifeSciences I Ltd.*, 545 U.S. 193, 202–08 (2005); Agreement Relating to Community Patents, Dec. 15, 1989, art. 27; European Parliament and European Council Directive 2004/27, art. 1.8(6), [2004] OJ L136/34 (EC) (amending Council Directive 2001/83 art. 10 (EC)); Carlos M. Correa, *Multilateral Agreements and Policy Opportunities*, Policy Dialogue 11 (2008); Frischmann, *An Economic Theory*, *supra* note107, at 995–97; Peter Lee, *Patents, Paradigm-Shifts, and Progress in Biomedical Science*, 114 Yale L.J. 692–93 (2004); *cf.* Rochelle Cooper Dreyfuss, *Reconsidering Experimental Use*, Akron L. Rev. (forthcoming 2017). *See generally* Holzapfel & Sarnoff, *supra* note *.

[165] *See* TRIPS Agreement, *supra* note 133, Art. 30; Panel Report, Canada – Patent Protection of Pharmaceutical Products, WTO Doc. WT/DS114/R, ¶¶ 7.54–7.57, 7.69 (adopted Apr. 7, 2000): *Competition & Tax Law, Declaration on the Three-Step Test*, Max Planck Institute for Intellectual Property (2009), www.ip.mpg.de; Holzapfel & Sarnoff, *supra* note *, at 175–79; Maskus & Okediji, *Intellectual Property Rights*, *supra* note 15, at 32; Pamela Samuelson, *Reverse Engineering Under Siege*, Berkeley School of Information 1–3.

[166] *Cf.* Reichman, *International Perspectives*, *supra* note 131, at 139, 1140–41; Abdel-Latif, et al. *supra* note 29, at 30–31.

[167] Maskus & Okediji, *supra* note 15, at 8.

[168] Aseem Prakash, Greening the Firm: The Politics of Corporate Environmentalism 152 (2000) (claiming that "firms adopt beyond-compliance [policy] initiatives primarily to preempt even more stringent regulations or to shape future regulations."); Overwalle, *supra* note 22; Chien, *supra* note 160.

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One set of ownership measures would be for upstream owners to retain the power to authorize experimental uses (to the extent that any jurisdiction lacks such restrictions on patent rights) and to permit "humanitarian" uses (at low or no cost) for climate mitigation and adaptation needs.[169] A second ownership measure would change the default resort from exclusive to nonexclusive licensing (unless the former has been demonstrated to be needed).[170] Such measures would be adopted voluntarily by patent owners in the first instance, and thus should encounter no legal concerns and should not trigger inter-governmental retaliation. In contrast, new legal requirements (or at least regulatory policy-based choices) may be needed for government agencies to *condition* private ownership of government-funded inventions on the preservation of such retained rights and default licensing policies.

Rather than for owners to start at the most restrictive level and for governments through regulation to have to override such choices, the retained rights approach can start at the most permissive level and ratchet up or differentiate restrictions if there are insufficient grantees or licensees to accept the initially offered conditions. Nonexclusive licensing of government-funded inventions thus could be required by law or regulatory policy as a default, and appropriately differentiated in response to market conditions or unforeseen circumstances. Such changes can be made much more quickly and more readily in response to market conditions than trying to reverse the effects of broad initial grants of rights for full patent terms through *ex post* regulatory measures and more formal adjudications.

Related to this approach (and therefore it is not treated as a separate measure) would be the greater use of patent holder and other IP rights-holder pledges, which could include nonexclusive and reasonable cost licensing, as described in detail by Jorge Contreras.[171] Pledges are:

> [public] commitments voluntarily made by patent holders to limit the enforcement or other exploitation of their patents. These pledges encompass a wide range of technologies and firms: from promises by multinational corporations like IBM and Google not to assert patents against open-source software users; to commitments by developers of industry standards to grant licenses on terms that are fair, reasonable, and nondiscriminatory (FRAND); to the recent announcement by Tesla Motors that it will

[169] *See, e.g.*, Peter Lee, *Contracting to Preserve Open Science: Consideration-Based Regulation in Patent Law*, 58 Emory L.J. 920–38 (2009); National Research Council, *Managing University Intellectual Property in the Public Interest*, National Academies Press 7 (2010) (discussing (Mar. 6, 2007) *In the Public Interest: Nine Points to Consider in Licensing University Technology*), https://otl.stanford.edu/documents/whitepaper-10.pdf); Paul A. David, *Mitigating "Anticommons" Harms to Research, in Science and Technology: New Moves in "Legal Jujitsu" against Unintended Adverse Consequences of the Exploitation of Intellectual Property Rights on Results of Publicly and Privately Funded Research*, 2 W.I.P.O. J. 59, 69 (2010); *see* About Science Commons, Science Commons, http://sciencecommons.org/about; Alan B. Bennett, *Reservation of Rights for Humanitarian Uses*, *in* Intellectual Property Management in Health and Agriculture Innovation: A Handbook of Best Practices 41 (Anatole Krattiger et al. eds., 2007); Carol Mimura, *Technology Licensing for the Benefit of the Developing World: UC Berkeley's Socially Responsible Licensing Program*, 21 J. Assoc. Univ. Tech. Managers, 15, 17–24 (2007).

[170] *See, e.g.*, Reichman, *International Perspectives*, *supra* note 131, at 1137; Anthony D. So et al., *Is Bayh-Dole Good for Developing Countries? Lessons from the US Experience*, 6 PLoS Biol. 2080–81; *see, e.g.*, Abdel-Latif, et al., *supra* note 29, at 15.

[171] Jorge L. Contreras, *Patent Pledges: Between the Public Domain and Market Exclusivity*, 2015 Mich. St. L. Rev. 787.

not enforce its substantial patent portfolio against any company making electric vehicles in "good faith."[172]

3 Leveraging Private Licensing and Technology Transfer Choices through Government-Funding Regulatory Policies and International Exhaustion Laws

The final two sets of innovation policy choices cut across public regulatory policies and private sector ownership initiatives. The first set of measures would clarify "march in" criteria under the US Bayh-Dole Act (or equivalent legislation in other jurisdictions), where the government retains rights to assure the working of patents or the accessibility of inventions created with government funds.[173] The second set of measures would clarify international "exhaustion" requirements to adopt permissive transfers without triggering patent rights, at least within certain geographical regions or among countries having similar levels of wealth or development.

March-in rights seek to facilitate access, but typically do so through cumbersome and controversial administrative processes (subject to judicial review).[174] *Ex ante* clarification of the conditions on which march-in should occur would allow governments more readily to march in when owners of patents funded with government money (or their licensees) fail to make the technology sufficiently accessible at affordable costs. As with conditions on licensees imposed through (private or government proprietary) ownership powers or that are imposed by law (such as the earlier proposals for research and interoperability exceptions to infringement), government-imposed presumptions of march-in conditions may have important signaling and demonstration effects, inducing private commercial entities to adopt similar conditional, nonexclusive, and reasonable-cost licensing policies.

Clarifying conditions for march-in *ex ante* should further reduce any concerns that might arise from use of such governmental power. If march-in does occur, the government's exercise of *agreed-to* conditions of the private party's "title" should pose much less concern for foreign direct investment or for other technology transfer mechanisms. Certainly, march-in should then pose much less concern than *ex post* compulsory licensing, price controls, or other *ex post* regulatory measures that governments inherently retain.[175] Governments, moreover, may retain "crown" rights or may otherwise authorize governmental conduct that would be infringing, in order to perform research or to produce patented products or provide patented services for public purposes.[176] Further, march-in rights are not needed if nonexclusive, reasonable-cost licensing is

[172] *Id.*
[173] *See, e.g.*, March-In Rights, 35 U.S.C. § 203(a).
[174] *See* March-In Rights, 35 U.S.C. § 203(b); Arti K. Rai & Rebecca S. Eisenberg, *Bayh-Dole Reform and the Progress of Biomedicine*, 66 Law & Contemp. Probs. 294 (2003).
[175] *Cf.* Fair, *supra* note 141, at 37 (posing concerns over loss of foreign direct investment from compulsory licensing).
[176] *See, e.g.*, Disposition of Rights, 35 U.S.C. § 202(c)(4); Domestic and Foreign Proteciton of Federally Owned Inventions, 35 U.S.C. § 207(a)(2); Sarnoff & Holman, *supra* note * (citing "Report of the National Institutes of Health (NIH), *Working Group on Research Tools, App. D*). The extent to which the government can rely on private parties to assist in exercising such retained powers without triggering infringement and required compensation – that may then be compensated under a "statutory takings" provision such as provided in the United States at 18 U.S.C. § 1498 – may be uncertain.

made a default condition for private parties to acquire title to rights in government-funded, private inventions in the first instance.

The final proposed measure would make greater use of the so-called "exhaustion" principle of patent law. Exhaustion permits parallel importation – importation of products produced and sold in other jurisdictions – and mandates unrestricted downsream (from initial sale) use and resale of patented technologies. It is a rapidly developing area of IP law and policy of increasing importance, and thus is treated at some length here.[177]

In theory, exhaustion should occur whenever patent owners or their licensees voluntarily supply a market, and thus obtain their "reward" through the first sale, even if the product is sold at low cost. Given the patent-holder's decision to itself make or otherwise authorize such low-cost sales, parallel importation of such sold products can achieve wider dissemination of climate change technologies that patent owners (or their licensees) voluntarily bring to the market. Thus, the public sector policy may have a dramatic effect on the private choices to transfer technologies across jurisdictions.

Given the global nature of the technologies and problems to be addressed, disputes over patent exhaustion are very likely to arise in the climate change context.[178] This regulatory policy choice has taken on even more significance in light of the US Supreme Court's recent decision in *Impression Products v. Lexmark*, which announced a policy of international exhaustion and automatic domestic exhaustion upon sale of patented technologies (including patented components of products).[179] The principle of "automatic" exhaustion of patent rights and the inability to constrain reuse or resale of patented products (and components) will dramatically affect the ability to engage in restrictive licensing for particular markets and for price arbitrage across jurisdictions with regard to mitigation and adaptation technologies (as well as for all other patented goods). Accordingly, international exhaustion runs the risk of encouraging patent holders not to sell to, or at prices that can be afforded by, some low-income jurisdictions.

Although the *Impression Products* opinion discussed preserving contract remedies to enforce such contractual restrictions following sales (in dicta),[180] it is possible that such contract remedies may (in jurisdictions that recognize such principles) be considered

177 *See generally* Research Handbook On Intellectual Property Exhaustion and Parallel Imports (Irene Calboli & Edward Lee eds., 2017).

178 *See, e.g., Get Ready for the Clean Tech IP Boom*, 182 Managing Intell. Prop., 44 (2008).

179 Impression Products, Inc. v. Lexmark Int'l, Inc., 137 S.Ct. 1523 (2017). *See, e.g., id.* at 1534–35 ('The misstep in this logic is that the exhaustion doctrine is not a presumption about the authority that comes along with a sale; it is instead a limit on "the scope of the *patentee's rights*.' . . . In sum, patent exhaustion is uniform and automatic. Once a patentee decides to sell – whether on its own or through a licensee – that sale exhausts its patent rights, regardless of any postsale restrictions the patentee purports to impose, either directly or through a license."); *id.* at 1536 ("Applying patent exhaustion to foreign sales is just as straightforward. Patent exhaustion, too, has its roots in the antipathy toward restraints on alienation . . . and nothing in the text or history of the Patent Act shows that Congress intended to confine that borderless common law principle to domestic sales. In fact, Congress has not altered patent exhaustion at all; it remains an unwritten limit on the scope of the patentee's monopoly.").

180 *See id.* at 1535, 1538 ("Once sold, the [patented products] passed outside of the patent monopoly, and whatever rights Lexmark retained are a matter of the contracts with its purchasers, not the patent law. . . . The purchasers might not comply with the restriction, but the only recourse for the licensee is through contract law, just as if the patentee itself sold the item with a restriction. . . . Exhaustion does not arise because of the parties' expectations about how sales transfer patent rights. More is at stake when it comes to patents than simply the dealings between the parties, which can be addressed through contract law.").

"preempted" by patent law. After all, it is only because of the "automatic" application of the principle of "exhaustion" that there is no meaning or effect to be given (as a matter of patent law and policy) to the contractual language that purports to restrict the transfer of such "authority" upon the first "sale" (so as to prohibit downstream uses or resales). And if this is so, it is hard to understand how enforcing such contractual provisions would not conflict with the legislated (national) policy of exhaustion; those contractual provisions would then permit the very same restrictions to be effectuated as a matter of (often subsidiary jurisdiction) *contract* law remedies. The questions of exhaustion and preemption will take many years to resolve. Similarly, questions also will arise and take years to resolve about whether such contractual restrictions on use and resale legally can be imposed by "licensing" rather than by "selling" patented products to the public (likely by combining such contract restrictions with mechanisms for "leasing" rather than "selling" the products).[181]

These matters necessarily will be decided under national laws of particular jurisdictions, raising potential conflicts of approach. This is because Article 6 of the TRIPS Agreement precludes international regulation by the WTO of national policies to address the exhaustion of patent rights and other IP rights, such as copyright.[182] Thus, national jurisdictions can adopt whatever approach they choose regarding the placing of goods on (first) sale or in use, so long as national treatment and most-favored-nation treatment principles are respected.[183]

Accordingly, nations will remain free to provide either or both international and domestic exhaustion effect to patented goods sold in foreign and domestic markets. This will permit low-cost resale and transfers from markets (or market segments) where patent holders have voluntarily placed goods on sale.[184] Correspondingly, to the extent that national law limits international or domestic exhaustion, firms can implement contractual policies that explicitly permit (as opposed to questionably prohibit) the same. Parallel importation measures to promote access thus can cut across both public law frameworks and private sector contractual arrangements.

In summary, these six sets of innovation policy choices collectively could help to mitigate concerns that IP rights will adversely affect innovation and access, as well as mitigate concerns for reducing *ex ante* investment and innovation incentives that inherently attend *ex post* government regulation by compulsory licensing, price regulation, or otherwise. Thus, these measures may help to accomplish the goals of promoting climate change technology R&D and assuring widespread access to such technologies at reasonable costs. Investors and inventors will know the limits of the patent rights, and can decide in advance whether the rewards warrant the limitations and risks. These proposals

[181] *See generally* Sean O'Connor, *Origins of Patent Exhaustion: Jacksonian Politics, 'Patent Farming,' and the Basis of the Bargain*, University of Washington School of Law Research Paper No. 2017–05 (Mar. 8, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2920738.

[182] *See, e.g.*, Kirtsaeng v. John Wiley & Sons, 568 U.S. 519 (2013) (international exhaustion of copyrighted works); Impression Prods., Inc. v. Lexmark Int'l., Inc., 137 S.Ct. 1523 (2017) (international exhaustion of patented works).

[183] TRIPS Agreement, *supra* note 133, Art. 6. ("For the purposes of dispute settlement under this Agreement, subject to the provisions of Articles 3 and 4 nothing in this Agreement shall be used to address the issue of the exhaustion of IP rights.").

[184] *See, e.g.*, Maskus, *Parallel Imports*, *supra* note 136, at 123–32.

also would encourage investors and inventors to make extensive use of private mechanisms in order to facilitate access and technology transfer.[185] Finally, greater use of these measures could help to avoid national resort to some of the more controversial measures that national governments retain under international IP and regulatory laws to assure greater access to and to regulate prices of patented climate-change-related goods and services.[186] They may thereby reduce international and trade tensions, and simultaneously reduce pressures to alter the international IP regime.

Conclusion

Climate change not only imposes unequal impacts and obligations, but also will lead to further unequal technology development and transfers, thereby imposing unequal costs on those who must suffer the impacts or shoulder the obligations. These inequalities will substantially impact the international regimes governing climate change, IP, and the implementation of the SDGs. PPPs raise particular concerns regarding the distribution of the benefits of the innovation policy choices that must be made when responding to climate change.[187] Institutional, network, and power effects may exacerbate existing disparities of innovative activity, wealth, and power globally in ways that generate additional global or domestic political tensions.

The turn to multi-stakeholder partnerships such as PPPs to implement international development policy, including the SDGs, is based on the recognition that globalization has already strained not only government efforts to develop human capital, but also the managerial competencies of both government bureaucrats and firm decision makers.[188] Whether in the public sector, the private sector, or PPPs, effective management of complex inputs and networks requires information that is rarely available, predictive judgments that are fallible, and skill sets that are in short supply.

In combatting climate change, greater reliance on PPPs must involve better evaluation of the spectrum of possible innovation policy choices, to avoid wasting massive resources and missing opportunities in the generation of desperately needed innovation outputs. At a minimum, public sector involvement in PPPs should provide more innovation funding, policy-making, steering and operational control, and oversight, in order to induce the market to supply additional funding.

185 *See generally* Chien, *supra* note 160.

186 *See* Sarnoff, *Patent System*, *supra* note *, at 333–60.

187 Powell, *supra* note 26, at 57–58 ("[S]cience policy is an effort to alter the trajectory, workings, and content of the social system of science with the relatively weak lever of control over some, largely formal, aspects of institutions. . . . [T]he institutional, network, and power mechanisms at work . . . have wider implications for legitimacy claims, labor market processes, industrial clustering, and race/gender inequalities that span many fields of science.").

188 Rising to the Challenge: U.S. Innovation Policy for the Global Economy 53, 118–21 (Charles W. Wessner & Alan W. Wolff eds., 2012) (discussing the need for human capital); Phillip Brown, Hugh Lauder & David Ashton, *Education, Globalization and the Future of the Knowledge Economy*, 7 Eur. Educ. Res. J. 131, 140 (2008) ("[V]irtually all [managers] we spoke to in China, Korea, India and Singapore, as well as the United States, Germany and Britain, believed that they were in a war for talent, which was increasingly global."); *see generally* Deborah Agostino et al., *Developing a Performance Measurement System for Public Research Centers*, 7 Int. J. of Bus. Sci. & Applied Mgmt. 43, 44–45 (2012) (discussing development of key performance indicators for performance management systems that balance the information needs of different stakeholders).

A more intentional approach to innovation management of PPPs also will require better understanding and tracking of innovation funding and other resource inputs and outputs, so as to better deploy the available innovation policies described here. In that way, PPPs will be better able to maximize the benefits of technology transfer generated through collaborative networks.

As stated in a recent summary of the conclusions of a World Bank Report, which addressed historic failures to achieve SDGs in regard to water supply, sanitation, and hygiene, achieving the SDGs will require changing innovation funding and technology development practices.

> [The report] suggests making three broad shifts to hasten implementation of the SDGs. They include: [1] coordinating investments and interventions across sectors to improve human development outcomes; [2] better targeting and efficiently allocating future investments, given the limited fiscal space of most countries; and [3] gaining a better understanding of the broader governance context within which [these] services are delivered, to bridge gaps between policy and implementation.[189]

These recommendations are equally applicable to climate change. But we would add two more recommendations (although the first is implicit in the World Bank's recommendations): [4] encouraging greater creativity and risk-taking in making innovation policy choices that overcome historic and political inertia; and [5] placing a greater emphasis on empathy and altruism, by rejecting the belief that climate change mitigation and adaptation are "someone else's problem."

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[189] Lauren Anderson, *World Bank calls for Broad Shift in Thinking to hasten* WASH, SDG Implementation (Aug. 29, 2017) (quoting World Bank Group, Reducing Inequalities in Water Supply, Sanitation, and Hygiene in the Era of the Sustainable Development Goals Synthesis Report of the Water Supply, Sanitation, and Hygiene (WASH) Poverty Diagnostic Initiative (2017)).

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