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THE SECOND ECONOMIC REVOLUTION, THE STATE, AND CLIMATE CHANGE

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(Discussion draft; comments welcome)

Changes in institutions, organizational structures, and shared beliefs that are taking place within major world powers may well affect the future path of climate change.[2] These factors will also heavily influence the choice and performance of measures adopted to counter harm from climate change. They should, then, be considered in assessing both the priority that should be accorded to the issue of climate change and the mix of remedies chosen to cope with it.

1. SCIENCE AND GOVERNMENT HARNESSED TO GROWTH

Climate change is perhaps the most troubling long-term environmental by-product of the second economic revolution.[3] Economic trends that began to gain momentum around the middle of the 19th century have already had effects as profound as those of the first economic revolution (the Neolithic Revolution), which gave birth to agriculture and urban life. This second revolution has created unprecedented wealth, but in the process, it has unleashed the threat of climate change. This section describes its origins. Section 1.1 considers the institutional roots of the linkage between science and technology. Section 1.2 offers a simplified sketch of the two main contrasting political logics on which modern states are based.

1.1. Roots of the knowledge-based economy

The modern economy arose from the confluence of two streams of innovations in social rules and norms, organization, and shared beliefs. One set of changes forged new bonds between science and economic production, and the other clapped tighter restraints on the

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[2] 'Institutions' refers to the formal and informal rules and norms that govern social behavior, including those that affect how rules are enforced and when they are not. Institutions, as North has put it, are the rules of the game and organizations are the teams that play it. Douglass C. North, *Institutions, Institutional Change, and Economic Performance* (New York: Cambridge University Press, 1990): pp. 3-4.

[3] J.R. McNeill, *Something New Under the Sun: An Environmental History of the Twentieth Century World*, (New York: W.W. Norton & Company, 2000) p. 108.

predatory urges of government. Both of these trends continue to unfold and both have major implications for climate policy; so a short description of them seems warranted.

The second economic revolution is truly revolutionary because it became self-sustaining. It has, in effect, never ended. Hence, its relevance to so current an issue as climate change. But the revolution's self-sustaining nature prompts an obvious question: why, for the first time in history, did a burst of innovation not eventually grind to a halt.

It did not do so, in part, because, with the rise of modern open science, discoveries led to yet other discoveries; further, scientific advance and industrial practice became linked. Discoveries in each led to progress in the other. The pool of useful knowledge from which innovators could draw was constantly refilled.[4] The chain reaction of discovery and invention went critical.

Before these trends could take their modern shape, state structures, education systems, and intellectual property rights had all to be greatly altered. Over time, a complex system of institutions covering open science, credit for priority, and standards of scientific proof emerged.[5]

The state, too, had to evolve in order to play its many current roles in the process of innovation. Today, it has come to serve as an educator and research funder, but it also acts as a gatekeeper.

Innovation creates both winners and losers; the latter have reason to attempt to block rise and spread of threatening technologies; if market barriers fail to stop innovation, its organized opponents may have recourse to non-market means.[6] The conflicts over transgenetic crops, nanotechnology, and hydraulic fracturing of gas and oil wells show that such moves are common.

1.2. Curbing government predation

The state was also central to the other set of changes that had been required before the second economic revolution could raise a full head of steam. For economic progress, the state must grow strong enough to protect is citizens from the depredations of foreigners, maintain law and order, enforce contracts, and provide other public goods.[7]

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[4] Joel Mokyr, "Innovation in an Historical Perspective: Tales of Technology and Evolution" in *Technological Innovation & Economic Performance*, eds. Benn Steil, David G. Victor, and Richard R. Nelson, (Princeton, Princeton University Press, 2002): p. 25; Joel Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy*. (Princeton: Princeton University Press, 2004): p. 19.

[5] Douglass C. North, *Structure and Change in Economic History*. (New York: W.W. Norton & Company, 1981): pp. 172-173.

[6] Op. Cit., Mokyr, 2004, p. 254.

[7] Mancur Olson, *Power and Prosperity: Outgrowing Communist and Capitalist Dictatorships*. (New York: Basic Books, 2000) pp. 11-13.

Yet the need for a strong state gives rise to Weingast's paradox: "A government strong enough to protect property rights and enforce contracts is also strong enough to confiscate the wealth of its citizens."[8] And, in fact, rulers have often found it in their interests to adopt a strategy based on socially destructive short term plunder.[9]

In other cases, though, a different pattern prevailed. Credible constraints on the ruler's ability to expropriate his subjects' wealth enabled faster economic growth, better equipped armies and navies, and sounder state credit.[10] By quite varied routes, a few societies have come to adopt arrangements that institutionalize such constraints on government predation.

These societies are, in fact, structured around a logic that differs from that which sustains most other states, present and past. These 'open access orders' have adopted rules allowing comparatively open entry into the contests for both wealth and power.[11] The resulting economic competition spurs the growth of output. At the same time, political competition holds state predation to low enough levels to enable the savings and investment needed to support robust long-term growth in output. This growth legitimizes the social order, encourages groups within it to support its rules and norms against challenges, and thereby deters such challenges.[12]

In contrast to this logic, most states throughout history have taken another approach.[13] This alternative is that of a limited access order, sometimes also called a 'natural state'. Such societies restrict access to both productive activity and the contest for power. And government uses the scarcity rents created by these entry barriers to buy the support, including the armed force, needed to maintain their grip on power.

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[8] Barry R. Weingast, (1995). "The economic role of political institutions: market-preserving federalism and economic development", *Journal of Law, Economics, and Organization*, 11.

[9] Op. Cit., Olson 2000, pp. 28-29.

[10] Douglass C. North, and Barry R. Weingast, "Constitutions and Commitment: The Evolution of Institutions Governing Public Choice in Seventeenth Century England", in *Empirical Studies in Institutional Change,* Lee J. Alston, Thrainn Eggertsson, and Douglass C. North editors, (New York, Cambridge University Press, 1996): p. 155; Nathan Rosenberg and L E. Birdzell, Jr., *How the West Grew Rich: The Economic Transformation of the Industrial World,* (Basic Books inc., New York, 1986): p. 265.

[11] Douglass C. North, John Joseph Wallis, and Barry R. Weingast, *Violence and Social Orders: A Conceptual Framework for Interpreting Recorded Human History*. (New York: Cambridge University Press, 2009): pp. 21-25; Daron Acemoglu and James A. Robinson, "Paths of Economic and Political Development" in *The Oxford Handbook of Political Economy,* Barry R. Weingast and Donald E. Wittman editors. (Oxford University Press, New York, 2006) p. 688.

[12] Barry R. Weingast, "The Political Foundations of Democracy and the Rule of Law" *The American Political Science Review*, 91, 2, June 1997, p. 261.

[13] Op. Cit., North et al., pp. 18-21.

2. SOCIAL STRUCTURES AND CLIMATE POLICY

Thus, the rise of new institutions, forms of organization, and patterns of shared beliefs enabled modern economic growth. Across wide regions, though, natural states still prevail. This section will describe impacts of current national social structures and climate change. Section 2.1 explains that the disparities in economic performance that exists between open order societies and natural states affect the risks posed by climate change. Section 2.2 offers examples of how the political economies of natural states raise their societies' greenhouse emission intensities. Section 2.3 explores features of climate policy that make it more susceptible to use as a pretext for rent seeking than most other issues. Section 2.4 refocuses to an open order polity, the U.S., and takes a cross-cutting look at how institutions affect the costs of the four main options for lowering harm from climate change.

2.1. A Coasean view of the climate problem

Many activities that are, in themselves, useful and valued raise costs elsewhere. Curtailing these useful activities would lessen the harm they do, but it would be costly. Further, those who suffer from ill-effects generated elsewhere might adjust their own behavior so as to lessen the harm they suffer. Insulating buildings against sound, for instance, could lower the nuisance costs of airport noise, as might simply moving the activities most susceptible to noise.

Faced with such a "reciprocal" problem, the best outcome, from a global standpoint, would be to make that set of changes that yields the greatest total benefit.[14] Often reaching that goal will mean inducing both parties to take measures to lower harm – one by controlling the source, the other by avoiding the effects. But motivating these corrective actions will, itself, incur transaction costs. Where those costs are high relative to the harm being done, inaction may be the best course.[15]

The issue of climate change exemplifies this logic. Greenhouse gas (GHG) emissions, by altering the climate, will impose costs on some activities. Yet rationing the use of fossil fuels, halting the felling or tropical forests, or shrinking livestock herds are themselves costly steps. To a degree, adaptation, climate engineering, or some combination, might offer lower cost means to reducing harm from climate change.

In fact, from a Coasean viewpoint, economic development of poor and middle income states is a promising approach to coping with climate change. It is a climate policy analogue to adding sound insulation to the buildings near airports. Development of these countries would doubtless raise greenhouse emissions; it would, though, also lessen the harm that they will endure from any given amount of climate change. For instance, development would lower these countries' dependence on climate-sensitive sectors; then

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[14] Ronald Coase, "The Problem of Social Cost", in *The Firm, the Market, and the Law*. (Chicago, The University of Chicago Press, 1988): p. 96.

[15] Ibid., p. 118.

too, it would provide wealth with which to adapt to ill-effects; and it would also bring gains unrelated to climate.[16]

How the benefits of economic development compare with the costs of the added emissions that it will cause will depend heavily on whether or not structural reform accompanies development. The institutions of natural states impede the growth that would help them to cope with climate change, and they also boost the GHG intensity of whatever growth does occur. Section 2.2 offers examples of both effects.

2.2. Natural states and emission intensity

One major drawback of economic growth as a means of lessening harm from climate change is that growth in natural states can often be more GHG intensive than it would be in open access orders. The bastions of market power that the governments of natural states need to control in order to maintain power do not merely lower economic output. They can also raise emission intensity. China and India, different as they are in many regards, both illustrate the point.

In the case of China, the growth of heavy industry is the main force behind rising emissions. It would remain a powerful driver of GHG growth even if all new investment used the most efficient world-scale technology.[17] State owned banks are funding the rapid growth of heavy industry. These banks pay little or no interest to depositors, but they also demand little of those borrowers with government backing.

As a result, the banks can invest in the state-owned enterprises (SOEs) in heavy industries well beyond the point of excess capacity. The SOEs have parallel incentives. On the one hand they cannot earn adequate returns on bank deposits. On the other, government demands so little in dividends from them that they are often awash in cash.[18] Output from the resulting excess capacity can be, in any case, shunted into export markets—thanks to the under-valued Yuan.[19]

The point to be stressed is that the source of high GHG intensiveness is not energy policy per se—though distorted prices there do add to the problem.[20] Rather, the problem is anchored in capital markets, and it cannot be excised without reforming those markets. Such reforms would be very likely to harm those with who are invested in the current heavy industrial SOEs. Yet the logic of the natural state dictates that such interests be co-

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[16] Thomas C. Schelling, "What Makes Greenhouse Sense? Time to Rethink the Kyoto Protocol", *Foreign Affairs*, 81(3): (2002): p. 3.

[17] Daniel H. Rosen and Trevor Houser, "China Energy: A Guide for the Perplexed." Center for Strategic and International Studies, Peterson Institute for International Economics, May 2007; 4.

[18] C. Fred Bergsten, Charles Freeman, Nicholas R. Lardy, and Derek J. Mitchell, *China's Rise: Challenges and Opportunities (Washington, DC: Peterson Institute for International Economics*, (Washington, DC: Peterson Institute for International Economics, 2008): pp. 148-149.

[19] Ibid., pp. 149-150.

[20] Ibid., p. 152.

opted into the ruling coalition. And the rising political power and independence of the SOE business elite implies that China has followed just this logic.[21] The task of reform must be more politically nettlesome than might at first appear to be the case.

In India, the political environment is, of course, vastly different, and the economy is far less GHG intensive. There too, though, governance problems, especially those in the electric power sector, raise emission intensity far above efficient levels.

Several factors are at work. State regulators hold electric power rates below cost; much power is stolen; lack of police protection may prevent power suppliers from denying services to non-paying customers; and subsidies often do not suffice to cover suppliers' financial shortfalls.[22] With power suppliers beset by financial shortfalls, capacity growth lags far behind that of demand, and service quality is poor. Many households are left without power. They revert to traditional sources of energy, and other customers, including many businesses, respond by building captive generators.[23] The household and diesel emissions that result are major sources of black carbon, an important factor in climate change.[24] So far, attempts at reform have had little effect.[25]

India's federal structure adds complexity. Governance in some states has improved markedly in the reform era; yet in other states, especially in the east, government is more an engine of corruption than as a source of public goods.[26] Reform legislation was enacted in 2003, but it has so far failed to inject much competition or efficiency into the power sector.[27]

Further reform remains politically difficult. While the growing numbers of middle class voters appear to favor economic reforms, many poorer voters are ill-informed about them; indeed, they appear to oppose their thrust.[28] In polities with competitive elections,

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[21] Erica S. Downs, "Business Interest Groups in Chinese Politics: The Case of the Oil Companies" in *China's Changing Political Landscape: Prospects for Democracy*, edited by Cheng Li (Washington, DC, Brookings Institution Press, 20008); p. 122.

[22] Montek S. Ahluwallia, "Economic Reforms in India Since 1991: Has Gradualism Worked?", in *India's Economic Transition: The Politics of Reforms*, ed. Rahul Mukherji, (New York, Oxford University Press, 2007): p.101.

[23] Pranab Bardhan, *Awakening Giants; Feet of Clay* (Princeton: Princeton University Press, 2010): p. 56.

[24] Robert E. Baron, W. David Montgomery, and Sugandha D, Tuladhar, "Black Carbon Mitigation" in *Smart Climate Solutions* ed. Bjorn Lomborg (Cambridge: Cambridge University Press, 2010): p. 142.

[25] Op. Cit., Bardhan, p. 56.

[26] Stuart Corbridge, "The Contested Geographies of Federalism in Post-Reform India", in *Understanding India's New Political Economy: A Great Transformation?*, eds. Sanjay Ruparelia et al., (New York, Routledge, Taylor & Francis Group, 2011): p. 72.

[27] Op. Cit., Bardhan, pp. 56-57.

[28] Ashutosh Varshney, "Mass Politics or Elite Politics? Understanding the Politics of India's Economic Reforms, in *India's Economic Transition: The Politics of Reforms*, ed. Rahul Mukherji, (New York, Oxford University Press, 2007): p.148; Radhika Desai, "Hindutva's Ebbing Tide? in *Understanding India's New*

large voting blocs, when organized by a party *apparat*, can use the power of the state to extract resources from less numerous interests, often at substantial cost to society.[29] This pattern helps to explain the failure of reforms to take hold in parts of India's economy where eliminating wasteful policies, though it would benefit society as a whole, would visibly harm the interests of large blocs like farmers or unionized workers.[30] Many of the distortions that result raise GHG emissions as well as lowering economic output.

2.3. Transaction costs and climate policy

Thus, the rent-seeking logic of natural states tends to add to the emissions intensity of their economies. It would, though, be a mistake to think that the political economies of open access order societies were free of rent-seeking. They are not, and features of the climate issue invite its use as a vehicle for rent-seeking.

Viewed from the supply side of the policy process, few officials will gain in either job security or power for pursuing climate change solutions. To spend time and effort on any issue entails opportunity costs. But, for a political actor, at least for one outside Europe, the benefits of progress on climate compare poorly with those of action on most other policy issues.

Benefits, if any, will accrue to future generations and often to foreign nationals. The likely supporters, therefore, may be of scant use in the struggle for power. Meanwhile voters and powerful interest groups must bear higher energy prices and costs.

In consequence, officials hoping to profit politically from offering climate 'solutions' often canvass for support among 'green' producer interests. Hence, mandates and subsidies for use of renewable energy, electric vehicles, and 'energy-saving' appliances are favored policy tools. Such approaches confer economic rents on well-organized interests. Officials can capture some of those benefits. The fact that the costs of these measures are both widely diffused and well-concealed from the wider public adds appreciably to their appeal to those on the supply side of the policy process.[31] No knowledgeable person, though, thinks that measures of this kind are close to being least cost ways to curb emissions—let alone to avoid harm from climate change.

To be sure, that the climate issue serves as a vehicle for rent-seeking hardly makes it unique. So too, other issues, including efforts to grapple with the fiscal burdens of aging populations, collide with the problem of making inter-generational transfers to the future. Climate change, though, faces added complications.

Political Economy: A Great Transformation?, eds. Sanjay Ruparelia et al., (New York, Routledge, Taylor & Francis Group, 2011): p. 173.

[29] Robert H. Bates, *Beyond the Miracle of the Market: The Political Economy of Agrarian Development in Kenya*, (New York, Cambridge University Press, 2005): p. 86

[30] Op. Cit., Varshney, p. 158.

[31] R. Douglas Arnold, *The Logic of Congressional Action*. (New Haven: Yale University Press, 1990): p. 9.

One acute problem is that the public can have no experiential evidence of a climate measure's benefits. With other pollutants, abatement measures either cause the air or water to get cleaner, or they do not. The public sees change or its absence. With climate policy, for the most part, the goal is to prevent some harm that might otherwise occur decades hence. Today's public can perceive neither the validity of the putative threat nor the efficacy of the proffered remedy. With real solutions both hard to enact and hard to explain, policy-makers can be tempted to resort to rent-seeking in sheep's clothing.

2.4. Climate policy options

The use of the policy process to implement climate solutions is, then, likely to incur hefty transaction costs in the form of inefficient measures adopted to satisfy rent-seekers. But, as noted in Section 2.1, several means are at hand for lowering the possible harm from climate change. And the transaction costs of moving these various options through the policy process, at least that of the U.S., are likely to vary.

GHG controls: In the U.S. federal level cap-and-trade bills have all failed. Allowance allocation, contrary to much ex ante speculation, did not seem to lower the transaction costs of moving bills through Congress. Indeed, its zero sum nature may even have raised such costs. In the end, most of these bills were heavily larded with provisions designed to confer economic rents on purveyors of one or another putatively green technology or to satisfy the policy preferences of single-issue advocacy groups. And even these flawed bills have failed to pass.

Instead, greenhouse gas control has served as a pretext for the growth of a dense thicket of mandates and subsidies. A decision by the U.S. Supreme Court has called forth a new command-and-control system under a statute regarded by all as ill-suited to the nature of the climate issue. None of the plans and proposals is linked to reciprocal action by other major emitters; the same is true of the EU's cap-and-trade system and its members' varied mandates; hence, these policies can have only marginal impacts on global climate. That being so, the gap between actual GHG controls and the steps that might affect climate at politically acceptable costs remains a wide one.

Adaptation: The poor prospects for GHG control underscore the importance of adaption to climate change. In this regard, the developed world has high capacity. In the U.S., a great deal could be done merely by reforming of western water rights and lowering subsidies to federal disaster insurance. And these same reforms would also generate social savings quite apart from any effect on future harm from climate change. That said, western water rights have long resisted change, and the transaction costs of change appear to be daunting; yet, the gains from reform are so large that, over time, barriers seem likely to crumble.[32] Fiscal pressure might offer a future chance to limit subsidies to disaster insurance, but to date, reform efforts have yielded little gain.

[32] Gary D. Libecap. "Water Woes: Using Markets to Quench the Thirst of the American West", *Milken Institute Review*, Fourth Quarter (2010): p. 68.

Adaptation can also entail changes in public works programs. History shows that public works projects have sometimes yielded large economic gains. At other times they have been hugely wasteful. The worry associated with such projects is their susceptibility to pork barrel politics. Growing fiscal stringency might tighten discipline on such programs.

Adaptation assistance: Adaptation in poor tropical countries presents bigger, harder to solve, problems. Such countries are more exposed to harm from climate change, and they have fewer resources with which to buffer its effects. To assist them, developed countries have pledged to contribute to what is supposed to become a $100 billion a year aid program to help poor countries adapt to climate change.

Proposals of this kind have one great virtue. They acknowledge, even if only tacitly, the reciprocal nature of the climate problem. That is, they recognize that the backward state of economic development in many parts of the world is a major source of concern about climate change. Such proposals reveal, in fact, that climate policy is partly a species of development aid.

Therein lies, too, their weakness. Over the last sixty-five years, the world has tried countless variants on development aid. A few have worked in some places; most have disappointed, and no clear formula for success has so far emerged.[33]

Many of the poorest states still lack institutions to rein-in government predation, and in most of the others, governments do not provide vital security. Development aid has often made governments less dependent on their own taxpayers. By doing so, it has actually enabled predation.[34]

Clearly, reforms of the kinds that benefited Modern Europe and its offshoots would greatly assist these vulnerable states. Yet such states fail to adopt institutions copied from those that have elsewhere succeeded. One reason may be that these governments face less pressure from inter-state military competition. Intense rivalries among the European great powers imposed a discipline on predation that has no analogue in Post Cold War Africa.[35]

Other barriers to reform are equally daunting. Many of today's weakest governments hold power by using the rents created by barriers to entry in both economic and political systems. Reform would dissipate those rents. In the process, it would threaten stability of the state itself, and, if anarchy is the alternative, even many interests not part of the ruling coalition may cling to the status quo.[36]

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[33] William Easterly, *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good*. (New York: Penguin Press, 2006): p.11.

[34] Robert H. Bates, *Prosperity and Violence: The Political Economy of Development*. New York: W.W. Norton & Company, 2010. p. 64.

[35] Ibid., p. 87.

[36] Barry R. Weingast, "The Political Foundations of Democracy and the Rule of Law" *The American Political Science Review*, 91, 2, (June 1997): p. 261.

The vexations of development aid have led some experts to propose more radical responses. In their view, if the some Third World governments of such countries cannot provide order, the international community could use armed force to provide it for them. In the face of severe forms of government predation, other states could use armed force to effect regime change.[37] Thus, the logic of adaptation aid in the face of institutional constraints leads to an altruistic, but muscular neo-colonialism.

Innovation policy: Stabilizing GHG levels at realistic costs will require breakthrough technologies.[38] The scientific and technical challenges are daunting. And policy challenges add to the difficulty.

The credible threat of future emission controls would induce added private sector R&D funding. Large scientific breakthroughs, though, require advances in basic science. Yet, the for-profit sector has weak incentives to do basic science research, and, in fact, the amount that it does is well below that which would maximize social welfare.[39] This fact has long been cited as a rationale for government-funded basic research.

Government energy R&D is, however, beset with institutional problems. Political actors' incentives rarely cause them to back high-risk, high-payoff R&D. For legislators, demonstration projects offer the prospect of creating jobs for constituents. And Congress, for this reason, is apt to hurry concepts into the demonstration phase. Once such projects are launched, office holders prolong funding for them long after they have ceased to yield public benefits.[40] The programs that result bear little likeness to economists' model of stable, but diversified, programs aimed at doing breakthrough research on game-changing technologies.[41]

The incentives that produce these perverse outcomes are deeply rooted in the institutions of government. The electoral process itself raises the political discount rate. Terms in office are short relative to the time lags inherent in R&D. Supporting R&D projects that

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[37] Paul Collier, *Wars, Guns, and Votes: Democracy in Dangerous Places*. New York: HarperCollins, 2009): p.232.

[38] Isabel Galiana and Chris Green, "An Analysis of a Technology-led Climate Policy as a Response to Climate Change," in *Smart Climate Solutions* ed. Bjorn Lomborg (Cambridge: Cambridge University Press, 2010): p. 302.

[39] Kenneth J. Arrow, "Economic Welfare and the Allocation of Resources for Invention" in *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Richard Nelson (ed). (Princeton, Princeton University Press, 1962): p. 619; Rosenberg, Nathan (1990). "Why Do Firms Do Basic Research (With Their Own Money)?" *Research Policy*, 19: 165-174.

[40] Jeffrey S. Banks, Linda R. Cohen, and Roger G. Noll, "The Politics of Commercial R%D Programs" in *The Technology Pork Barrel,* (Washington, DC: The Brookings Institution Press, 1991): pp. 73-74

[41] Kenneth J. Arrow, Linda R. Cohen, Paul A. David, Robert W. Hahn, Charles D. Kolstad, L. Lee Lane, W. David Montgomery, Richard R. Nelson, Roger G. Noll, Anne E. Smith, "A Statement on the Appropriate Role for Research and Development in Climate Policy", *The Economists' Voice*, 6(1): Article 6 (2008).

yield large, but diffuse, net benefits, and those only after a long time, is a poor re-election strategy.[42]

Climate engineering: Other kinds of R&D might also lead to climate solutions. At least two sunlight-based climate engineering (CE) concepts may be able to offset all the warming expected in this century.[43] One of them involves lofting a fine seawater mist into low-level marine clouds. There, the droplets would 'whiten' the clouds; *i.e.* they would cause them to reflect more sunlight[44] and perhaps lengthen their lives.[45] The second approach contemplates injecting very fine sulfate particles into the stratosphere.[46] After a year or two, particles would fall to the surface as rain or snow; the quantities would be small compared to current sulfate emission levels.[47]

Either approach offers the chance of large benefits. One hypothetical CE system has recently been estimated to yield net benefits with a discounted present value (in 2005 dollars) of $4 to $10 trillion.[48] One very important potential advantage of CE is that, in contrast to GHG controls, it might offer a relatively swift response should severe harm from climate change appear to be imminent.[49] Against these possible gains, though, policy makers must weigh the risk that CE might trigger costly side effects. Scientists have raised a number of fears.[50]

Climate engineering has not, as yet, generated strong interest within the U.S. The scale of the investments needed to implement it may be too modest for the concept to serve as a pretext for pork barrel politics. And the concept fits uneasily into the ideologically polarized political landscape. Many of the green groups are inclined to oppose it as a way of evading emission controls. Those on the right continue to reject the existence of a serious problem.

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[42] Op. Cit., Banks et al., pp. 57-58.

[43] Tim M. Lenton & Nem E. Vaughan, "The Radiative Forcing Potential of Different Climate Geoengineering Options", 9 *Atmospheric Chemistry & Physics Discussions* 5339, 5539 (2009): p. 5553.

[44] John Latham, et al., "Global Temperature Stabilization via Controlled Albedo Enhancement of Low-Level Maritime Clouds", *Philosophical Transactions of the Royal Society* (2008): p. 3969.

[45] Keith Bower, et al., "Computational Assessment of a Proposed Technique for Global Warming Mitigation via Albedo-Enhancement of Marine Stratocumulus Clouds", 82(1-2) Atmospheric Research 328, (2006): p. 329.

[46] Alan Robock, et al., "The Benefits, Risks, and Costs of Stratospheric Geoengineering", 36 *Geophysical Research Letters* (2009): pp 4-7.

[47] Paul J. Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?", 77(3-4) *Climatic Change* (2006): p. 213.

[48] J. Eric Bickel and Lee Lane, "An Analysis of Climate Engineering as a Response to Climate Change", in *Smart Climate Solutions* ed. Bjorn Lomborg (Cambridge: Cambridge University Press, 2010): p.40.

[49] Ibid., pp. 20-21.

[50] Alan Robock, "20 Reasons Why Geoengineering May be a Bad Idea," *Bulletin of the Atomic Scientists*, 64(2): (2008) 14-18.

3. CLIMATE POLICY AND THE INTERNATIONAL STATE SYSTEM

The international state system will affect the four just-described climate strategies in different ways. This section considers how international politics might affect each of these strategies. Again, major differences are evident.

3.1. GHG control

To be effective GHG controls would require the major powers to construct a global regime on abatement. Regimes consist of "implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations."[51] Four problems shadow efforts to build an effective GHG control regime.

First, as Section 2.4 notes, actual controls are far from optimal; therefore, costs of implementing them could easily exceed the benefits.[52] Hence the store of rewards from which states might be compensated for the costs of reaching, enforcing, and complying with an agreement would appear to be meager at best.

Second, national preferences over climate differ widely. Rich temperate-zone states have less to fear from it than do poor ones in the tropics. Then too, transaction costs are raised further because so many states are involved, their values differ widely, and trust among many of them is scarce. Such factors raise the transaction costs of defining property rights.[53] In principle, those states most anxious to curb emissions could offer side payments to those that are opposed or indifferent. In practice, the prospect of such payments encourages all states to display reluctance in hopes of being paid.[54]

Third, a coalition of great powers willing to coerce other states would is most unlikely to emerge. Coercion is often costly for those applying it.[55] Further, the states best able to impose controls are those with high and rising emissions and high bargaining power. Most such states, though, are less threatened by climate change than are poorer states. The bargaining power of the latter is too feeble for them to have much impact on the course of events.

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[51] Stephen D. Krasner, "Structural Causes and Regime Consequences: Regimes as Intervening Variables", *in Power, the State, and Sovereignty: Essays on International Relations* (Stephen D. Krasner ed. (New York: Routledge, 2009): p. 113.

[52] Richard S.J. Tol, "An Analysis of Mitigation as a Response to Climate Change", in *Smart Climate Solutions* ed. Bjorn Lomborg (Cambridge: Cambridge University Press, 2010): p. 95.

[53] Lee J. Alston and Bernardo Mueller, "Property Rights and the State," in *Handbook of New Institutional Economics*, Claude Ménard and Mary M. Shirley (eds.), (Dordrecht: Springer, 2008): p. 581.

[54] Paul Collier, *The Plundered Planet: Why We Must – and How We Can – Manage Nature for Global Prosperity,* (New York: Oxford University Press, 2010): p. 178.

[55] Lloyd Gruber, *Ruling the World: Power Politics and the Rise of Supranational Institutions*, (Princeton: Princeton University Press, 2000) p. 37.

Fourth, the weakening of U.S. hegemony decreases the odds of a successful bargain. The most powerful state in the global system has typically taken the lead in coercing and cajoling others into joining and obeying regimes.[56] Since WWII, the U.S. has often played that role, but on GHG control the lack of a U.S. domestic consensus has led the EU to try to fill this vacuum. That effort has failed. Absent a state willing and able to act as an effective leader, the transaction costs of regime building rise.[57]

3.2. Adaptation and adaptation assistance

Adaptation depends less on international cooperation than does GHG control. National preferences over adaptation may differ, but, in most cases, each country may act as it chooses.

The task of managing trans-border fresh water resources is one exception. However, the past record, although mixed, is generally good. The relatively low value of fresh water has acted to mute conflicts. The question is whether greater stress on future fresh water resources will sharpen conflicts, and, if so, to what degree. States often derive some power advantage from an upstream position.

Adaptation aid is a different matter. Some developed countries, as noted above, say that they will aid poor tropical countries in their efforts to adapt to climate change. Concern for spillover effects from state failure motivates some of this concern.[58]

With efforts to use aid to head-off state failure the donor bears the costs of the aid, but many countries would benefit. Again, preferences vary. Nearby countries have more reason to fear spillovers than distant ones. Unlike the case of GHG control, a single major hold-out will not bring the entire effort to naught. Still, the past limits on the scale of aid funding testify to the difficulty of the free rider problem as much as to that of designing a program that achieves results.

The notion of using armed force changes the distribution of power and makes the option still less appealing to would be donors. Building good governments is many times harder than toppling bad ones. And as the scale of needed military force rises, the number of competent candidates falls off rapidly.

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[56] Robert Gilpin, *Global Political Economy: Understanding the International Economic Order*. (Princeton: Princeton University Press, 2001): p. 95.

[57] Keohane, Robert O. *After Hegemony: Cooperation and Discord in the World Political Economy*. (Princeton: Princeton University Press, 1984): p. 183.

[58] Susan Rice, "The National Security Implications of Global Poverty" in *Confronting Poverty: Weak States and U.S. National Security,* eds. Susan E. Rice, Corinne Graff, and Carlos Pasqual, (Washington, Brookings Institution Press, 2010): p. 6.

3.3. Innovation policy

R&D spending may be somewhat less subject to free rider problems than GHG control or even than adaptation aid. Japan's METI for one has suggested making climate related R&D a subject of international bargaining along with GHG controls.

Other proposals relate to demands that developed countries offer technology aid to less developed states. The latter have, so far, rejected such proposals. The case for them is in any case subject to much dispute. The benefits of disseminating existing technologies may well be less than those of maintaining current incentives for innovation. The high costs of today's abatement technology may argue, at least for now, for stressing innovation over the wider spread of current technology. But the value of IP protection seems to vary greatly by industry and IP system, throwing a cloud of uncertainty over the entire debate.

In adaptation, the dueling international regimes in transgenetic organisms appear to be retarding adoption in Africa of higher yield and more drought resistant seed varieties. Eliminating this barrier would seem likely to open a path to major benefits. History tempers hopes about the prospects for such a breakthrough.

3.4. Climate engineering

The global political challenge of CE differs from those implied by other approaches. CE's relatively low engineering costs imply that any major state could probably afford to do it. But differences in preference over climate among the great powers could spark conflict over the nature, scope, and timing of CE.

The risk that CE would trigger sanctions by a great power would be likely to deter a middle ranked state from deploying a CE system. It may be less potent with regard to another great power. Sanctioning great powers has rarely been tried, and when it has, it has often not worked.[59]

Another option, though, could affect bargaining power. It might also be technically possible to counter-act at relatively low cost the cooling effect of CE.[60] Clashing CE systems would clearly raise concerns about harmful side effects; this risk would turn CE into a game of chicken in which the state that attempted cooling could be as likely to swerve as the one that sought to block its efforts.

In response, major states might seek to build an international regime on CE. Such states, by virtue of their might, would automatically have a voice in decisions about CE. It

[59] Daniel W. Drezner, *All Politics is Global: Explaining International Regulatory Regimes*, Princeton: Princeton University Press, 2007): p. 34.

[60] Correspondence with Gregory Benford.

remains unclear how many states would be likely to be included. One recent plan envisions a list of around fifteen,[61] and this number may not be too far off the mark.

4. INSTITUTIONAL TRENDS AND THE FUTURE OF CLIMATE POLICY

The previous two sections have pointed out ways in which national institutions and the realities of global politics seem likely to affect efforts to limit harm from climate change. But many factors outside the realm of climate policy are likely to impact the future path of climate change. In this regard, trends in the institutions that launched the second economic revolution may bear watching as future influences on climate.

4.1. Changes in the pace of technological advance

Some experts object that high technical barriers to progress in GHG control suggest that the IPCC is projecting unrealistically high rates of innovation.[62] Historically, though, institutions have also affected the pace of innovation. Some economists worry that the complex of institutions that has so far fostered rapid innovation in the world economy as a whole may be in danger. Three factors warrant notice.

First, aging populations, and the fiscal burdens they imply, may limit governments' future financial support for basic science. Since basic science is critical to the process of innovation, the threat, should it materialize, would be serious. The U.S., European, and Japanese populations are aging. Some level of fiscal stringency seems certain to follow, and, at least in the U.S. public spending on R&D had already begun to feel a pinch.[63] The future path of innovation may, therefore, hinge on how deeply relevant R&D will be cut and how well governments apportion the remainder.

Second, in the view of some, the "privatization of the scientific commons" prompts concerns about the soundness of foundations of open science. The institutions and group structures that undergird this enterprise stand outside the market nexus.[64] Examples include open science, credit for priority, and standards of scientific proof.

Moves to expand the scope of patent rights and to draw researchers more directly into proprietary research may raise the costs of using existing knowledge as an input to further

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[61] This plan was voiced by Ambassador Richard Benedick at the 2010 Asilomar International Conference on Climate Intervention Technologies. See: Eli Kintisch, "Scientists Call for 'Climate Intervention' Research with 'Humility,'" *ScienceInsider*, March 26, 2010.

[62] Op. Cit., Galiana and Green, pp. 195-196.

[63] Peter S. Heller, *Who Will Pay? Coping with Aging Societies, Climate Change, and Other Long-Term Fiscal Challenges,* (Washington, D.C.: International Monetary Fund, 2003). Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (Washington, DC: The Brookings Institution Press, 1997): pp. 58-59.

[64] Richard R. Nelson, "The Market Economy, and the Scientific Commons", (2006) http://www.law.umich.edu/centersandprograms/lawandeconomics/workshops/Documents/winter2006/nelson.pdf. p. 2.

research.[65] At the extreme, the growing sway of market forces might threaten the organizations and institutions essential to open science.[66] Without them, innovation may wane.[67] And with public sector financial support for science sinking, the pressures to court market-based funding seem likely to build.

Third, and perhaps most troubling, the strength, and number, of interests with a stake in retarding innovation seem to be growing. Over time, technological progress creates more and more vested interests. Those interests seeking to foster rules that freeze in place the status quo. Does progress, therefore, give rise to a complex of rules that eventually stifles its own advance?[68]

The answer remains unclear. One the one hand, there seems to be evidence that resistance to innovation is growing at least within the developed world. The accretion of status quo forces is much like that predicted in Mancur Olson's *The Rise and Decline of Nations*. On the other hand, though, the pace of innovation has not demonstrably slowed.[69]

4.2. New open orders or the implications of failure

Levels of government predation may also be in flux. If major emitters like China, Indonesia, or India were to shift discernibly in the direction of becoming open access orders, the effects on both climate change and climate policy might be momentous. Ceteris paribus, economic growth would rise, GHG intensity would fall, and more market based emission controls would become more feasible, though they might not become much more likely.

If North, Wallis, and Weingast are correct, China must eventually become more open politically if its economic growth is to continue. The Communist Party may contemplate some kinds of reform, but it seeks to confine change within bounds consistent with its retaining a monopoly on political power.[70] The latter depends heavily on limiting entry into both politics and economic activity.

Some trends hint that the limits to its flexibility may be fast approaching. In recent years economic reform has stalled, triggering speculation about a trapped transition.[71] A so-

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[65] Ibid., p. 7.

[66] Op. Cit., David, p. 13.

[67] Paul A. David, "The Historical Origins of 'Open Science': An Essay on Patronage, Reputation and Common Agency Contracting in the Scientific Revolution," *Capitalism and Society* 3(2): 5. (2008) p. 6.

[68] Op. Cit., Mokyr p. 278.

[69] Ibid., p. 275

[70] Andrew J. Nathan, "China's Political Trajectory: What are the Chinese Saying?", in *China's Changing Political Landscape: Prospects for Democracy*, edited by Cheng Li (Washington, DC, Brookings Institution Press, 20008); p. 39.

[71] Minxin Pei, *China's Trapped Transition: The Limits of Developmental Autocracy*. (Cambridge: Harvard University Press, 2006). P. 31.

called left-wing opposition has gained prominence. The implications for the regime of a long-term slowing in per capita income are murky.

India's political economy, of course, differs greatly from China's. It clearly is a relatively stable political democracy.[72] Its path toward an open order society is, though, no more clear. The analysis cited in Section 2.4 notes that reforms have garnered some degree of elite support, but they have also met popular resistance.[73]

Several barriers appear to impede further liberal economic reforms. Perhaps in so diverse a society, governments must expend so much effort in merely maintaining control that they lack the political and social capital, the trust, to effect major reforms.[74] Then too, patronage networks are widespread in India.[75] Such networks may help to maintain cohesion. But political 'machines' based on the local credibility of patrons tend to favor narrowly targeted rent-seeking policies instead of those based on supplying more welfare-enhancing public goods.[76] This pattern of politics is inimical to further liberal reform.

The point is that China and India are large enough for their future course to notably affect the pace of climate change. Both have undergone astonishing institutional change. Yet both countries might make the transition to a fully open access society, fail to do so, or involve in some direction as yet not known or predicted. The smooth unfolding of current trends seems no more probable than are sharp discontinuities. The latter, though, would seem to portend quite different futures for climate change, the world economy, and global politics.

5. SOME IMPLICATIONS FOR CLIMATE POLICY AND ITS ANALYSIS

The foregoing analysis may suggest a number of points relevant to climate policy analysis.

First the poorer economic performance of natural states amplifies the risks posed by climate change. Economic growth in these states could greatly lessen the global costs of climate change. But these states' institutions cause growth there to be needlessly GHG intensive. They also make long-term growth harder to sustain. Without institutional

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[72] Charles Tilly, *Democracy*, (New York, Cambridge University Press, 2007): p. 55.

[73] Op. Cit., Bardhan, p. 126.

[74] Op. Cit. Tilly, p. 57.

[75] Bruce Bueno de Mesquita et al., *The Logic of Political Survival*, (Cambridge, Massachusetts, MIT Press, 203): p. 471.

[76] Philip Keefer and Razvan Vlaicu, "Democracy, Credibility and Clientelism" World Bank WPS-3472, at http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2005/02/02/000009486_20050202165259/Rendered/PDF/wps3472.pdf p. 26.

reform, programs to aid adaptation and sustainable development will have no more success than have their predecessors.

Second, the rules and norms that govern both national and world politics will impose hefty political transaction costs on all measures intended to counter the ill-effects of climate change. These costs are likely to be higher in the case of climate policy than with most other issues. GHG controls and adaptation assistance seem especially subject to high political transaction costs.

Third, the social structures that foster innovation and those that define the patterns of government predation in major emerging economies are not static. Large changes in these structures may lie ahead. That possibility injects what appear to be large, though so far unaccounted for, uncertainties into all efforts to descry the future course of climate change.

Fourth, international organizations may shy from treating some of the harsher logic of politics. One can understand and even sympathize with the reaction. And it may be incorrigible. If so, it is all the more important for independent scholars to correct the lacunae that result. The issue may raise a larger question: is there a need for an organizational base from which to conduct a more unflinching analysis climate change and other global issues?