# Korea's Environmental Sustainability Leadership in East Asia and Beyond*

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Environmental problems but especially those related to greenhouse gas (GHG) emissions present huge collective action difficulties, as the sources of the problems are local while the effects are trans-national. Efforts to control pollution can also limit rapid growth, but it is claimed here that application of the newest advancements in GHG-related technology can mitigate some of these costs. This paper examines the potential for the combined mobilization of science and technology (S&T) on the one hand, and global and regional coordination on the other with particular attention to Korea's prospective role in Northeast Asia. With its robust "green growth" strategy, streamlined bureaucracy, and firm-led GHG-related S&T output, Korea is poised to facili-

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tate regional research projects and technology transfer. Without a more concerted emphasis on basic R&D in this area, though, its breakthrough technologies will lead only to marginal, short-lived increases in productivity.

**Key Words:** Greenhouse Gas (GHG), Science and Technology (S&T), Innovation, Green Growth, Korea, Sustainability

## I. Coordination Problems and Korea's Green Growth Strategy

Efforts to address environmental problems at the international level are plagued with collective action difficulties. The sources of environmental problems are typically national or local, but the effects can cross both immediate and distant boundaries. This scenario is particularly acute with regard to greenhouse gas (GHG) emissions, which are a key attribute of anthropogenic climate change. At the international level, there has been a lot of activity by the UN,[1] the World Bank, and international non-governmental organizations to address GHG emissions, but domestic policymakers have been largely reticent in promoting changes which would decrease GHGs. There are a number of hazards and conflicts of policymaking, described generally by Stone (2001) and in a two-level coordination model by Putnam (1988). For example, the effects of reductions in GHGs are long-term, cross-national, and largely uncertain (in terms of degree). This certainly does not offer the greatest maximum benefit to the policymaker, who makes

1. See, for example, the "Global Green New Deal" proposed by the United Nations (UN) in late 2008, which simultaneously addresses problems related to the environment and to rising levels of unemployment.

changes at the margins, where reductions of GHG emissions are cheapest and easiest (Fischer and Newell, 2008) and where S&T policies and output have the potential to reduce these costs (Stavins, 2003; Jaffe et al., 2004).

Environmental pollution is also treated by governments as an externality or residual of economic growth, specifically that treating the problem risks detouring the country from rapid growth. For example, increases in the use of hydropower, wind, solar, geothermal, and tidal energy ultimately decrease GHG emissions but at the expense of cheap, fossil fuel-based energy generation. This is, of course, without taking into account the costs involved with setting up the infrastructure to accommodate these renewable energy sources. Furthermore, the possibility that fossil fuels can continue to be used as an energy source via advances in science and technology (S&T) is contingent on research and development (R&D) or the purchase of such R&D output. Carbon capture and storage, for example, is currently undergoing tests for feasibility but its success will reap the greatest rewards for the inventing nation, whether by decreased energy generation costs or through the generation of licensing fees.

Many of the keys to solving pollution and GHG emissions problems involve S&T. If mobilized effectively, science can help mitigate some of the lost economic development costs associated with reducing GHG emissions. In other words, S&T advances make clean-up less of a zero sum game between pollution and economic development. Thus, environmental issues can be resolved through the combined mobilization of S&T on the one hand, and either global or regional cooperation on the other. This is the central premise of this discussion, and it is one within which the East Asian region offers an excellent opportunity for closer analysis, particularly Korea's role as a model of sustainability and its unique opportunity to address environmental spillover problems which, given the science differentials, should encourage bilateral, regional, and international cooperation. At the regional level, which will be given focus here, there is still resistance to cooperating, whether due to historical tensions or nationalism. The inherent conflict is that successful cooperation at the regional level provides the most efficient way of treating environmental problems such as GHG emissions through advances in S&T. This argument provides an important extension to the dynamics of East Asian regionalism described by Pempel (2006).[2]

The analytical method used in this paper is distinct from other analyses which are rooted in the macro-level. Applying a standard production function framework to the relationship between GHG-related patents and sources of R&D funding at the country level, Shapiro (2009) determines there are degrees of both market failure and government failure in R&D. At the macro-level, though, case-specific information is much less entertained, which is the distinct advantage of using a micro-level analytical approach, given that R&D can be affected by policies non-uniformly.[3] For example, in the three decades following World War II, Korea and other countries in the East Asian region implemented a selection of industrial and international economic policies to achieve sustained economic growth and development. In the immediately following period, from the mid-1980s to the early twenty-first century, policies shift-

2. Pempel (2006) emphasizes horizontal production networks, foreign direct investment, and export processing zones.
3. If the government provides extensive support to private sector research efforts, concerns about knowledge spillovers lead the firm to invest less than the socially optimal level of R&D. Such market failure may be remedied in a number of ways by the government, particularly through public-private R&D consortia (Stiglitz and Wallsten, 1999). However, if the government is funding the most commercially promising proposals they receive, they are effectively supporting projects that firms would likely have financed on their own (Wallsten, 2000), resulting in government failure. On this count, David et al. (2000) find no conclusive evidence that government-funded R&D crowds out private-funded R&D.

ed toward science and technology (S&T) output and the fostering of research capabilities. This pattern is largely consistent with the pattern of technological catch-up described by Nelson and Phelps (1966), as universities, government research institutes (GRIs), and firms increased the competitiveness of the national innovation system.[4] In the last eight to nine years, despite intra-regional differences, these efforts have not diminished but have been supplemented with specific targets to address greenhouse gas (GHG) emissions and other climate change-related phenomena.

Korea can potentially lead the region with its GHG-related S&T efforts. The mechanism through which this is presently occurring is the Lee administration's "green growth" strategy, which emphasizes the "3Es": energy security, economic efficiency, and environmental protection. Overseeing this directive is the National Energy Committee, which is headed by President Lee Myung-bak and a number of government officials, business leaders, academics, and civic group leaders. Outlined by the Ministry of Knowledge Economy (2008), specific 3E-related goals for the year 2030 include a reduction of energy intensity by 46 percent and fossil fuel consumption to 61 percent from its current 83 percent, an increase in renewable energy use to eleven percent from 2.4 percent in 2007, the establishment of energy technology output on par with the world's most advanced countries, and the provision of affordable energy to Korean citizens.[5]

Each of these goals — improvements in energy efficiency, reduction in energy consumption, increases in the supply of clean energy, and assurance that Korean citizens will continue to afford

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4. National innovations systems are defined and treated comparatively in Nelson (1993).
5. The "577 Initiative" of the Lee administration (establishing by 2012 five percent of GDP in R&D, focus in seven core process areas, and performing as one of the seven major S&T entities in the world) also treats GHG-related S&T output, particularly in terms of global issues-related technologies.

energy under these changing circumstances — can be further analyzed in this preliminary assessment of the Lee administration's green growth strategy. A complete study of Korea's green growth strategy, or an overall assessment of Korea's innovation, such as OECD (1996, 2009), would underemphasize GHG- and sustainability-oriented S&T foci offered here. Our analysis is also limited by the fact that R&D of this sort can be particularly time intensive, so the precise connections between Lee Myung-bak's green growth policies and GHG-related output is tenuous at best. Path dependency has a necessary place in this discussion, though, and it will be shown that the Lee administration's ability to successfully implement its environmental policies and agenda is based in no small part on existing environmental policies and research output.[6]

Our attention next turns to the environmental efforts and S&T output of Korea. As was just stated, S&T output is long-term in nature, so we cannot attribute this directly to the relevant changes implemented by the Lee administration; yet, it is the foundation upon which Korea's green growth strategy is built and must be given due attention. To provide a sense of how Korea has performed relative to its neighbors in Northeast Asia and to qualify our emphasis on collective action problems, policies and S&T output for Japan, Taiwan, and China are also presented below.

## II. Changes in Korea's Innovation Governance Structure

The Lee Myung-bak administration's approach to innovation policy and its subsequent relationship to S&T output related to sustainability is largely consistent with election promises to better

6. "Path dependence" is considered here in the context of Nelson and Winter (1982).

integrate Korea's innovation and educational policies. This campaign pledge is intimately connected to President Lee's other pledge to decrease the size of government. It will be shown here that the ability to successfully address and foster sustainability in line with the green growth strategy is a function of alleviating coordination problems within government. This must not occur, however, at the expense of market-failure correcting R&D funding to government research institutes (GRI) and, in particular, universities. Basic R&D is typically generated out of university-based research efforts.

Coordination problems in the period before 2004 are particularly outlined by Schueller et al. (2009). They claim that, in this period, there was a lack of power to coordinate, there were weak linkages between policies and the budget process, and there was an overall lack of understanding of S&T at a policy level. At that time, the innovation governance was dispersed across administration, intermediaries, industry, and a research and education system, with coordination efforts attempted and led by the Ministry of Science and Technology (MOST), the S&T minister, and the Office of the Ministry of Science, Technology Innovation (OSTI). For Korea, though, MOST represented an innovation governance structure consistent with "developing" country status. To address this outdated characteristic as well as the coordination problems, education and basic research has been merged within one ministerial apparatus — the Ministry of Education, Science & Technology (MEST) — and industry and applied research under another — the Ministry of Knowledge Economy (MKE), as shown in Figure 1. These ministries are also involved in creating market-based incentives for GHG reductions through the tax system, reliable signaling, a cap-and-trade system, the establishment of the Green Growth Committee,[7] and the Green New Deal Policy.[8]

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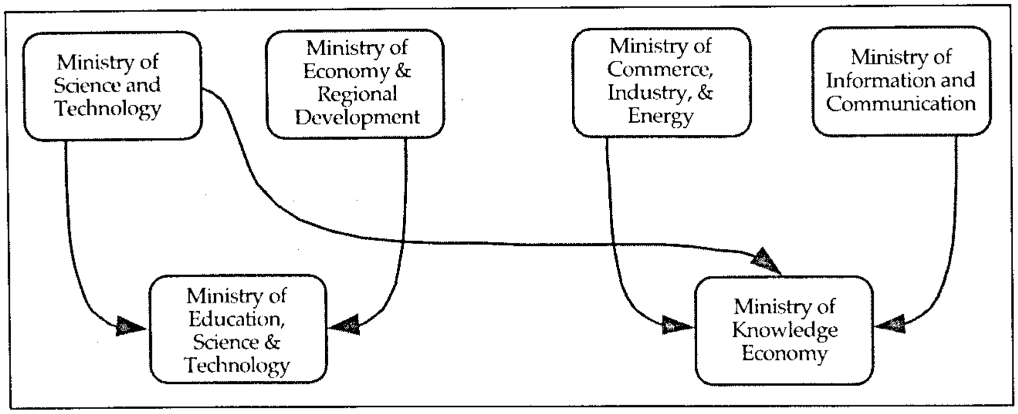
7. The Green Growth Committee is comprised of a total of fifty individuals

*Figure 1. Ministerial Restructuring under the Lee Administration*




Beyond attempts to fulfill campaign pledges, institutional restructuring was completely necessary because earlier restructuring attempts failed to resolve coordination problems (Schueller et al., 2009). These changes also represent a return to the type of institutional structures and goal-driven policies in place during the heavy-chemical industrialization drive of the 1970s, illustrated more clearly with Korea's response to the international financial malaise from 2008. As reported by HSBC (2009) and presented in Figure 2, the share of green stimulus funding (e.g. low carbon power, energy efficiency, etc.) from total stimulus funding is highest in Korea. At more than eighty percent, Korea's green stimulus funding ratio is more than all other countries, irrespective of regional affiliation. China's share of green stimulus funding at approximately thirty-eight percent ranks the next closest overall. Also, within the region, Japan's share of post-crisis stimulus funding devoted to green pursuits is under three percent. In real terms, Korea's emphasis on sustainability is third across all countries, and in terms of the total amount of green stimulus funding, it follows

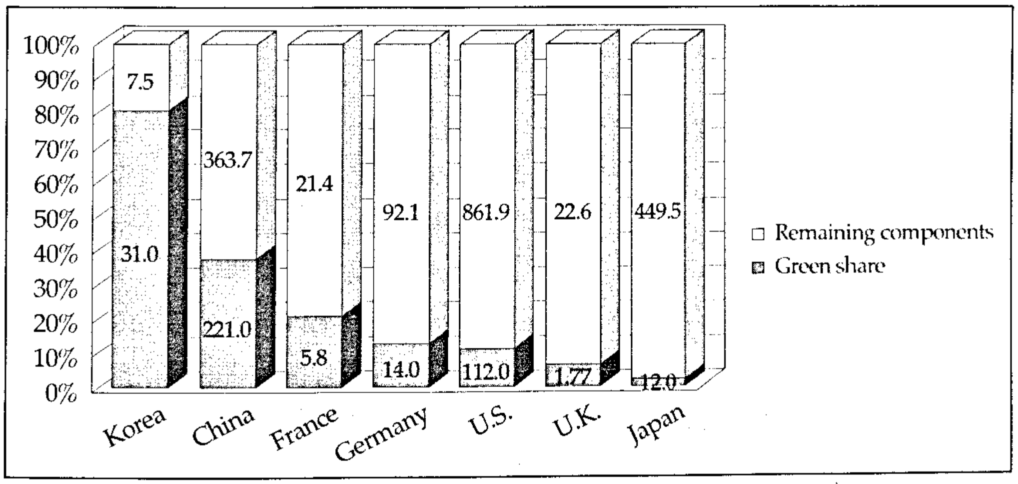
from the public and private sectors to coordinate policies and implementation strategies.

8. The Green New Deal Policy is designed to create jobs in industries oriented toward sustainability.

only China (US$ 221 billion) and the U.S. (US$ 112 billion). As well, Korea's total amount of green stimulus funding (US$ 31 billion) is more than double that of the next highest ranked country, Germany (US$ 14 billion).

*Figure 2. Recovery-Based Sustainability R&D*

(billions of U.S. dollars)




Korea is not the only country in Northeast Asia with an innovation governance structure in place to treat sustainability. Japan's S&T efforts now reflect the third installment of the Science and Technology Basic Law originally enacted in 1995.[9] The Third Basic Plan (2006-2010) is subdivided into six goals, including sustainable development defined as economic growth combined with environmental protection. The major R&D themes, thus, include climate change, hydrological cycles and solute transport in watersheds, ecosystem management, 3R (reduce, reuse, recycle) technologies, and biomass utilization technologies. In addition, the largest share of S&T budget allocations for 2009 are for low-carbon technologies,

9. The First Basic Plan (1996-2000) targeted increases in government expenditures and a new R&D system; the Second Basic Plan (2001-2005) focused on increases in the knowledge base and increasing the competition for research funds.

at 164 billion yen (Wada, 2009).[10] The emphasis on low-carbon technologies is also indicative of Japan's long term approach to S&T, further exemplified with the 2025 end goal of the "Innovation 25" guidelines and the "Cool Earth 50" proposal (from the 2007 G8 summit) to halve global GHGs by 2050. Taiwan's Agenda 21 approaches sustainable development in a general sense, with details offered in the National Environmental Protection Plan and the Sustainable Development Action Plan (Republic of China Executive Yuan, 2004). As well, the Basic Environment Act of 2002, Article 23, makes a call for the fostering of green industries and non-nuclear renewable energy sources, and there is institutional support from the Ministry of Economic Affairs (Bureau of Energy), which is focused on sustainability and efficiency as core goals of Taiwan's energy policy. Greater amounts of R&D subsidies from the government are a policy prescription in pursuit of these goals (Chen, 2008), represented with the establishment of the Taiwan Industrial Greenhouse Office (TIGO) under the Ministry of Economic Affairs, in 2006.[11] Finally, China has had a strategy for sustainable development in place since 1996 (Rongping, 2009), but its pattern is exceptional. While energy efficiency and environmental preservation are outlined in very clear terms, a notable absence from this strategy are efforts to mitigate or even address GHGs. This pattern is also identified in the case study of air pollution policies for the region, to which we now turn.

Korea's environmental legislation relating to sustainability is highly specific, illustrated with a cursory analysis of air pollution

10. Breaking it down, innovative technologies receive 52.3 billion yen, S&T diplomacy receives 46.7 billion yen, regional (domestic) system promotion receives 69.3 billion yen, and public-private R&D projects receives 19.5 billion yen.
11. TIGO was established specifically to reach a GHG-reduction goal of ten percent (based emissions levels in 2000) by 2015, and it is also responsible for coordinating the various agencies within the Ministry of Economic Affairs in pursuit of GHG reductions and the technology to satisfy these efforts.

regulations, which most aptly address GHGs, specifically carbon dioxide (CO2), methane, nitrous oxides (NOx), and chlorofluorocarbons (CFCs). The Clean Air Conservation Act of Korea (CACAK) treats the aforementioned GHGs with the most detail, covering a variety of topics related to air pollution, including the regulation of marine and motor vehicle emissions, incentives for low emission vehicles, air quality assessment standards, program funding, interaction with other laws, emissions costs, and violation penalties. Article 2.2 of the Act includes the following among the list of GHGs: CO2, methane, NOx's, hydrofluorocarbon, perfluorocarbon, and sulfur hexafluoride, the latter effectively expanding the list of GHGs. Articles 11 and 16(5) allow for the government to set an emissions performance standard, with the former assigning the responsibility of developing a comprehensive plan for the improvement of the atmospheric environment to the Ministry of Environment. This includes the monitoring of existing GHG levels, the setting of GHG reduction goals and methods to achieve such goals, and jurisdiction over international cooperation regarding climate change. Article 16(5) empowers the Minister of Environment to set emissions standards stricter than those established by Ordinance of the Ministry of Environment in areas that have been designated as "special measures areas," including those in which environmental damage excessive. Article 35 essentially allows the government to impose an emissions price on businesses that emit GHGs and Article 58 allows for the government to subsidize the adoption of renewable fuel technology for vehicles.[12]

Compared to related legislation within the region — the Law

12. More specifically, Article 58(1) allows the heads of local governments to order that the owners of light vehicles convert their vehicles to low-pollution vehicles. Article 58(2) allows the state or local governments to provide loans or subsidies to those who purchase low emissions vehicles, convert existing vehicles to low emissions standards, and setup zero emissions fuel stations.

Concerning the Promotion of the Measures to Cope with Global Warming (Japan), the Bill on Amendments of the Climate Change Policy Law (Japan),[13] the Basic Environment Act of 2002 and the Air Pollution Control Act (APA) (last revised in 2006) of Taiwan, and the National Eleventh Five-Year Plan for Environmental Protection (2006-2010) and the Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution in China — the CACAK is most thorough and direct. Indeed, China should use this legislation as a model for future air pollution regulations. China's National Eleventh Five-Year Plan for Environmental Protection (2006-2010) and the Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution make nearly no reference to GHGs or climate change. Extensive details are offered to reduce the amount of sulfur dioxide (SO2) emitted from coal burning power plants, but nothing is mentioned of the substantial amount of carbon dioxide that accompanies sulfur dioxide as a pollutant from these plants.

This close reading of Chinese environmental regulations reveals a lack of requirements to periodically assess air quality and to make such assessments public. More importantly, there is excessive decentralization of enforcement regulations in China, resulting in coordination problems, especially given Beijing's record of government failure resulting from over-decentralization.[14] In Article 3 of the Chinese law, for example, it lays the responsibility on the local governments to ensure that the law is upheld within their jurisdictions. This is precisely the type of structure which Presi-

13. We selected these two regulations from Japan rather than the Air Pollution Control Law of 1996, which primarily treats SO2, soot, and other air pollutants.
14. In China, for example, one of the most severe problems plaguing the CCP is the lack of oversight of local CCP officials. Beijing regularly imprisons or executes corrupt officials, but this can be interpreted as a symptom of the problem rather than a solution.

dent Lee is moving away from and offers clear evidence of the regulation-innovation governance connection.

There is also reason to suspect that President Lee's attempts to increase coordination efforts of S&T will do much for the country's GHG-related output. Based on development paths, our expectations that Japan's output is greater than Korea's is confirmed through an analysis of patent and publication data. Again, this does not capture the changes applied since President Lee took office, which should be manifested in terms of GHG-related output by mid-2010 at the earliest.

Patent data is becoming increasingly reliable and accessible as a measure of innovation output, verified by attempts to bolster the integrity of patent statistics, such as OECD (2008). There are many aspects of GHG patent output which must be detailed, especially as this specific patenting area has been given virtually no attention in the existing literature. Publications, as well, have been given scant attention in the literature in terms of their GHG focus. Data collection for patents and publications has been done through the online patent and publications search functions of the USPTO and the Web of Science, respectively. The parameters of this search are based on two criteria: inclusion of either "greenhouse effect" or "greenhouse gas" in the patent description or the article's topic.[15]

15. For patents, the issue date is distinct from the filing (or priority) date in that the former typically occurs from one to four years after the latter. More importantly, the filing date is not available until the patent has been issued, and it simply is not an available search parameter. Thus, when collecting patent data, it is particularly important to account for the filing date to sufficiently represent the effects of the time lag between the application and issue dates. Also drawn from the USPTO search function are the issue date-ordered patent numbers, the assignee's country of origin, and the inventor's country of origin. More specific details on the inventor(s) is also collected, such as whether the inventor is at a university, a government research institute (GRI), or at a firm, and whether the inventor's institution is also the assignee's institution. If the assignee has no affilia-

These keywords are by no means all-inclusive parameters to capture the degree of GHG-oriented innovation,[16] but a cursory analysis of a number of keywords over the relevant time period confirms that these two terms are greatest in number and cover the widest area of industry classes.[17]

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tion, this is also noted. Given the international scope of this analysis, non-English-based institutions were frequently left in their language of origin, calling for translation and further research. Fortunately, there are a number of computing-based tools available to facilitate this process, but the search itself was time consuming, especially when determining whether a GRI is in fact under the direct guidance and funding of the government or whether it functions as a corporation. The United States patent codes (USPC) have also been collected from the USPTO, both major and minor.

16. The top nine most patented industries in GHG-related output are: chemistry of inorganic compounds; power plants; refrigeration; wells; chemistry — electrical current producing apparatus, product, and process; compositions; chemistry — molecular biology and microbiology; liquid purification or separation; and gas separation — processes.
17. Within these two key terms there also exists the issue of relevancy, as there may be correlation between "greenhouse effect" and "greenhouse gas" and non-sustainability-oriented innovations. The original, uncleaned dataset includes 1,050 patents for the period from 2000 to 2008. Within this data however, USPC 47 — plant husbandry — appeared seventeen times, only one of which was relevant to a discussion of GHGs. The remainder was specific to the greenhouse effect as it was used in the original context: the phenomenon of keeping plants warm through glass paneled or plastic housing. Thus, of these seventeen patents, only one has been included in the final version of the dataset used in this analysis. Similarly, the four patents listed under USPC 52 (static structures, e.g. buildings), one under USPC 135 (tent, canopy, umbrella, or cane), two under USPC 219 (electric heating), one under USPC 237 (heating systems), eleven under USPC 296 (land vehicles, bodies and tops), one under USPC 351 (optics, eye examining, vision testing and correcting), five from USPC 362 (illumination), one under USPC 385 (optical waveguides), and ten from USPC 428 (stock material or miscellaneous articles) use one of the key terms in a context other than sustainability-oriented R&D. Patents which specify carbon neutrality, carbon sequestration, photovoltaics, wind turbines, or renewables are indeed components of sustainability-oriented innovation, but parsing out the most relevant patents requires much more care.

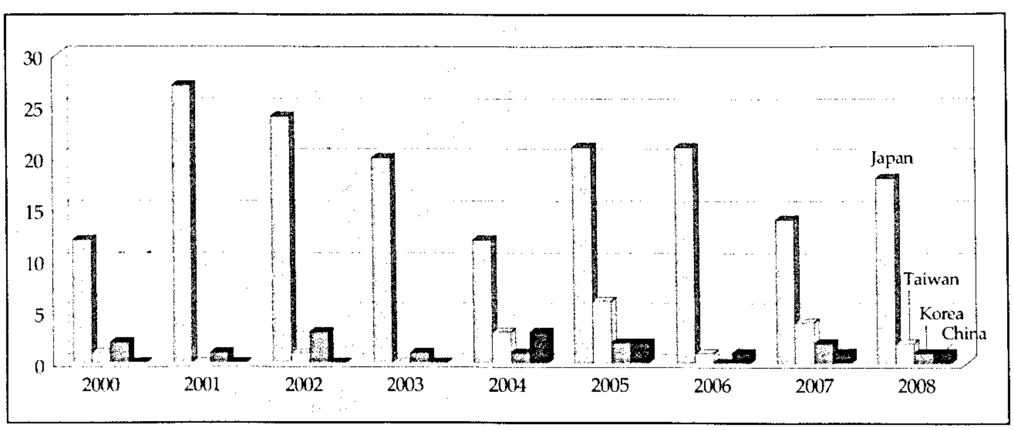
*Table 1. GHG-related Output 2000-2008 by Country*

| Patents | | | Publications | | |
|---|---|---|---|---|---|
| Rank | Country | Total Patents | Rank | Country | Total Publications |
| 1 | U.S. | 544 | 1 | U.S. | 1500 |
| 2 | Japan | 173 | 2 | U.K. | 587 |
| 3 | Canada | 68 | 3 | Canada | 505 |
| 4 | France | 51 | 4 | Germany | 442 |
| 5 | Germany | 48 | 5 | Australia | 296 |
| 6 | U.K. | 21 | 6 | Netherlands | 239 |
| 7 | Korea | 19 | 7 | Japan | 235 |
| 8 | Taiwan | 18 | 8 | France | 231 |
| 9 | Australia | 16 | 9 | China | 208 |
| 10 | Italy | 16 | 10 | Italy | 158 |
| 11 | Switzerland | 12 | 11 | Sweden | 147 |
| 12 | Norway | 11 | 12 | Switzerland | 144 |
| 13 | Netherlands | 9 | 13 | India | 103 |
| 14 | Sweden | 9 | 14 | Denmark | 99 |
| 15 | China | 8 | 15 | Finland | 97 |
| 16 | Belgium | 5 | 16 | Brazil | 91 |
| 17 | Finland | 4 | 17 | Russia | 89 |
| 18 | Island | 4 | 18 | Belgium | 86 |
| 19 | Denmark | 3 | 19 | Spain | 86 |
| 20 | Lichtenstein | 3 | 20 | Austria | 82 |
| | | | 21 | N. Zealand | 73 |
| | | | 22 | Taiwan | 58 |
| | | | 23 | Turkey | 48 |
| | | | 24 | Poland | 40 |
| | | | 25 | Korea | 35 |
| | | | 26 | Mexico | 32 |
| | | | 27 | Thailand | 27 |
| | | | 28 | Greece | 24 |
| | | | 29 | Indonesia | 21 |
| | | | 30 | Portugal | 21 |

* Source: USPTO (2009) and ISI (2009).

Globally, GHG-related output — both patents and publications — is dominated by the U.S. Presented in Table 1 for the 2000-2008 period, Japan is the second-most innovative country and trails the U.S. by around a factor of three. At the same time, Japan has been producing more than three to four times more patents than Taiwan, Korea, and China combined, over the 2000-2008 time period. Nevertheless, China is producing GHG-related patents on par with a number of European countries, while Korea and Taiwan take up the seventh and eight positions among the world's most GHG patenting countries. These are relatively unremarkable positions, given that Germany, in fifth position, and Canada, in third position, have twice and (over) thrice as many patents, respectively. Within the region, presented in Figure 3, Taiwan has shown the most dramatic increase in GHG-related patents when comparing the pre- and post-2004 periods. GHG-related publications are a very different story, with China producing nearly as many as Japan over the 2000-2008 period and taking on exponential proportions (see Figure 4). The trends described in this section indicate that Korea, as well as Taiwan and China, are well on their way to becoming major producers of GHG-related technologies, albeit still trail far behind Japan in terms of patents. The peaks and

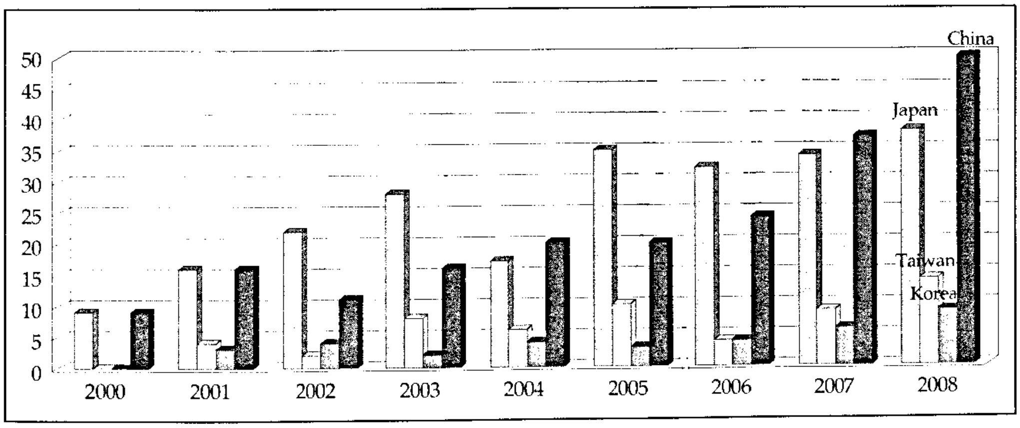
*Figure 3. GHG-related Patents by Assignment Date*




* Source: Author's calculations using USPTO (2008) data.

valleys presented in Figures 3 and 4 are not strong confirmation that the future will hold sharp upward trends, but the proposed and implemented policies should support such an increase.

*Figure 4. GHG-related Publications*




* Source: Author's calculations using ISI (2009) data.

## III. Suggestions and Opportunities for Global and Regional Coordination

Environmental regulations and especially those treating GHG emissions have generated strong responses from supranational entities such as the UN, the World Bank, and international non-governmental organizations. For domestic policymakers, the long-term, cross-national, and uncertain (in terms of degree) impacts of GHGs make it a relatively unattractive cornerstone for any environmental agenda, given the hazards and conflicts of policymaking in general, described by Stone (2001), and the two-level coordination problems modeled by Putnam (1988). Nevertheless, in this section, we examine the international institutions and how Korea and its neighbors have taken advantage of global programs.

International environmental coordination began with the 1965 UN Development Program, which has helped distribute funds and support in the interests of biological diversity and global warming. The UN Environmental Program was created in 1972 by the Stockholm Conference to oversee cross-national environmental concerns and monitor the environment on a global scale. The Convention on Long Range Transboundary Air Pollution was initiated in 1979, and the Montreal Protocol to address pollution affecting the ozone layer was first ratified in 1987. In 1992, the UN Commission on Sustainable Development was created to monitor the programs which began through the 1992 Rio conference (United Nations, 1993).[18] Sustainable development was revisited and updated once again in 2002, on the tenth anniversary of the Earth Summit at the World Summit on Sustainable Development in Johannesburg. In the interim, the UN Millennium Development Goals (MDG) arose from the Millennium Summit in 2000 to determine the function of the UN in the 21st century. These eight goals are effectively the largest attempt to address GHG emissions in tandem with other sustainability-related measures. From 2006, the Kyoto Protocol to the United Nations Framework Convention on Climate Change was officially implemented, but the MDGs are distinct from the Kyoto Protocol, which focuses on reductions in greenhouse gases by industrialized countries.

More recently, support for international coordination was offered by Hillary Clinton (2009), who attempted to rally the world behind the revamped American effort to approach climate change at the international level. She proposed an action plan oriented around science and technological efforts but also maintained that the knowledge will not flow freely to the developing world.[19]

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18. In this case, sustainable development can be defined in terms of generational impacts, where the needs of the present are met without compromising the future's ability to meet their own needs (WCED, 1987).
19. It is encouraging that the energy and environmental landscape has changed so rapidly in Washington, given the large and growing consensus of the anthropogenic sources of GHGs. Policymakers, interest groups,

Japan, Taiwan, Korea, and China are participants in the UN (although Taiwan was formally replaced by mainland China in 1971).[20] They are all involved with what is perhaps the greatest contribution of UN-based programs to anthropogenic climate change: the Clean Development Mechanism (CDM). Schneider et al. (2008) attest that the CDM affords developing countries the opportunity to receive key technologies, although institutional barriers may limit such transfers. China has been the most prevalent recipient of CDM projects, amounting to 1,682 of a global total of 4,660, or 36 percent of all CDM projects (UNEP Risoe, 2009).[21] Among these 1,682 projects, 239 (14.2 percent) are initiated out of Japan, although it is in Korea's interest to engage intensively in technology transfer to China through the CDM.

Region-based efforts are not without their own set of challenges, and these four countries can make significantly more progress at regional cooperation. Nam (2002) has found that the Northeast Asia region is plagued by political and institutional constraints to regional environmental policy coordination, despite the ecological interdependence and the shared air pollution, yellow dust, and marine pollution.[22] There have certainly been a number of bilateral and multilateral efforts within the region, such as the Environment Congress for Asia and the Pacific, the Northeast

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business leaders, and a more informed public are turning increasingly to the research community for solutions. This is consistent with historical examinations of technological advances and their related social and economic outcomes. If Rosenberg's (1982) observations of innovation affecting the long-run economic viability of key resources such as steel, aluminium, and coal are any predictor of how S&T may affect GHG emissions, tracking research output is an absolute necessity.

20 Korea became a formal member of the UN in 1991, Taiwan in 1945, Japan in 1956, and China in 1971 (when it formally replaced Taiwan as the "true" Chinese member).

21. India represents another 26 percent of the total number of CDM projects.

22. See Lee (2002) for more details on these three interdependencies.

Asian Conference of Environmental Cooperation, the Northeast Asian Subregional Program of Environmental Cooperation, the Northwest Pacific Action Program, the Tripartite Environment Ministers Meeting, and discussions at regional economic fora (APEC, ASEAN plus Three). Yet, key studies such as Nam (2002) and Lee (2002) omit from their analysis the two driving forces of this paper: S&T efforts and supra-regional (i.e., international) targets of GHGs.

The greatest potential for the East Asian countries to establish GHG-related connections within and beyond the region lies in the Asia Pacific Partnership on Clean Development and Climate (APPCDC). This voluntary partnership involves Australia, Cana-

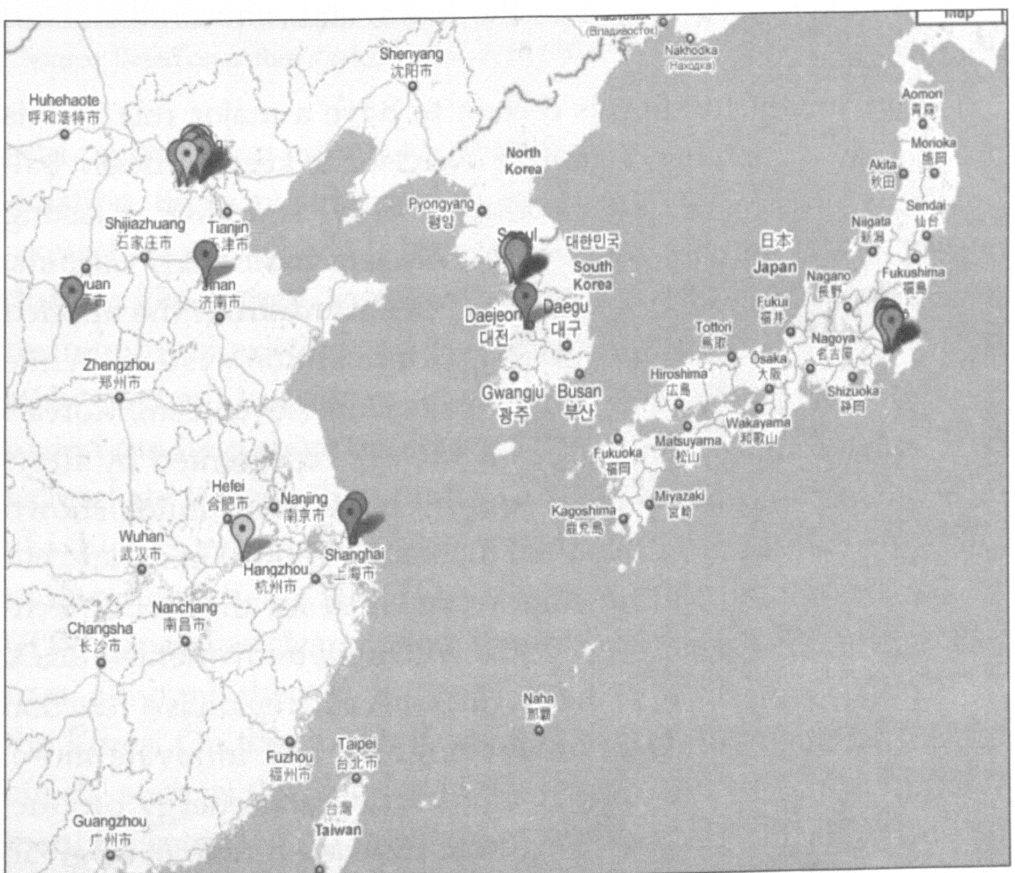
*Table 2. Source of Existing APPCDC Agreements for Select Countries*

| | Japan | Korea | China |
|---|---|---|---|
| Aluminum Task Force | ATF.06.06 | | ATF.06.02 |
| Buildings and Appliances Task Force | BATF.06.03 | BATF.06.01<br>BATF.06.06 | BATF.06.04<br>BATF.06.07 |
| Cleaner Fossil Energy Task Force | CFE.06.07 | CFE.07.16 | |
| Cross Cutting and Other | | | CCO.07.04 |
| Coal Mining Task Force | | | CLM.06.11<br>CLM.06.12<br>CLM.06.16 |
| Cement Task Force | CMT.06.01<br>CMT.06.02<br>CMT.07.10 | CMT.07.09 | CMT.06.05 |
| Power Generation and Transmission Task Force | | | PGT.06.12 |
| Renewable Energy and Distributed Generated Task Force | RDG.06.15<br>RDG.06.16 | RDG.06.04<br>RDG.06.11<br>RDG.06.17<br>RDG.06.24 | RDG.06.05<br>RDG.08.33<br>RDG.08.34<br>RDG.08.35 |
| Steel Task Force | STF.06.02 | STF.06.03 | STF.06.04 |

* Source: Asia-Pacific Partnership (2009).

da, China, Japan, Korea, and the U.S., with a goal of developing key technologies. Classified as a technology-oriented agreement (TOA), this has been found to be more successful than the broader UN-based agreements listed above (De Coninck et al., 2008), excluding the CDM. A list and map of current projects within Northeast Asia are presented in Table 2 and Figure 5, respectively. APPCDC is an ideal case study for future analyses of the mitigation of GHGs in the context of R&D and S&T in Northeast Asia, integrating a spectrum of industries with direct connections to anthropogenic climate change. As is the case with the CDM, performance and outcome measures are not yet available for the APPCDC.

*Figure 5. APPCDC Projects in East Asia*




* Source: ([http://data.mapchannels.com/embed/appprojects.htm]).

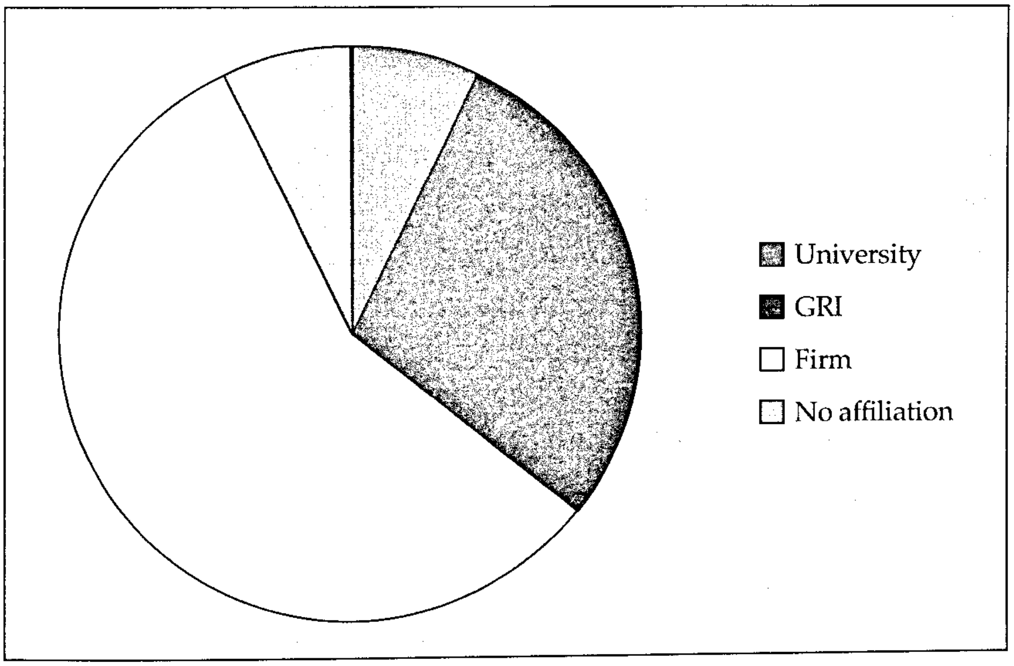
## IV. Conclusion

There is an increasingly robust relationship between international accords and domestic policymaking with regard to the environment. This can be most recently observed in the U.S. with the Obama administration's leadership in having carbon dioxide classified as a pollutant, for which many countries in the international community had been advocating for a number of years. The context of this discussion, though, has been recent changes to Korea's innovation governance structure, past GHG-related S&T output, and future potential given the Lee administration's green growth strategy. Post-election changes indicate a focused, government-directed attempt to establish the country as a GHG-related technology provider, much the same way that it dealt with steel production in the 1970s, textiles in the 1980s, and semiconductors in the 1990s and 2000s.

Government funding is certain to have a major role in this process, but there must be caution exercised to keep sufficient balance between the goals and priorities of MEST and MKE. A lasting impact will be possible only with sufficient basic R&D outputs, which would represent a significant departure from the applied focus typical of the Korean national innovation system. While based on a relatively small sample of patents (seventeen), Korea's GHG-related innovation output is heavily represented by firms relative to universities and government research institutes, shown in Figure 6. Of course, patents are inherently applied in nature, but universities should still be more represented for the sort of technology which is typically associated with long-term oriented R&D.

The economic force of the Northeast Asian region is a function of its continued ability to innovate, grow, and innovate more. Without updates to existing manufacturing and energy production methods, the medium/long-term costs are certain to be great, given the pattern of GHG emissions. While attempts to reign in

*Figure 6. GHG-based Patent (2000-2008) Breakdown by Research Entity*




* Source: Based on author's calculations using USPTO (2009).

acid precipitation output are evidence of successful regional coordination, there must be greater S&T focus on carbon capture and sequestration methods from existing fossil fuel-based energy production, bio-energy, increased energy efficiency, and increases in the number of existing and potential carbon sinks. China is moderately stagnant in addressing the long term effects of GHGs. The region can help shore up some of these deficiencies by advancing technology transfer through the CDM and the APPCDC, the latter of which is expected to have the benefits of technology transfer within a more efficient TOA framework. In the context of the CDM, Japan has clearly taken the lead among the East Asia countries, although there is no reason for a similar effort to arise from the Korea. On this count, Korea can also replicate other Japanese efforts, such as the Sino-Japanese Friendship Centers for Environmental Protection, to facilitate technology and inform the (Chinese) public. If partnerships on multiple levels are not occurring between Korea and China, there is a missed opportunity to deal with collective action concerns.

International research consortia are ideal, but region-based research efforts to address GHGs are an immediately viable alternative. Even in a non-GHG-related context, international R&D collaboration for all patents represents less than ten percent of all patent output (USPTO, 2009), so there is plenty of room for growth. There is even less occurrence in the case of GHG-related R&D. The U.S. is having difficulties managing its own affairs within North America and refuses to freely provide knowledge and technological output (Clinton, 2009). China — and the rest of the world, for that matter — cannot count on a bilateral debt-for-technology arrangement with the U.S.

## References

Asia-Pacific Partnership, "APP Project Roster" (2009) [http://asi asiapacificpartnership.org/english/project_roster.aspx].

Chen, Shih-Hau, "Elevated Vision, Enhanced Illumination Allowing Energy Policy to Shine Forth Again in Obscurity" (2008) [http://www.tier.org.tw/eng2008/eng_analysis/EA200806_4.asp].

Clinton, Hillary Rodham, "Remarks at the Major Economies Forum on Energy and Climate" (2009) [http://www.state.gov/secretary/rm/2009a/04/122240.htm].

David, Paul A., Bronwyn H. Hall, and Andrew A. Toole, "Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence," *Research Policy*, Vol. 29, No. 4-5 (2000).

De Coninck, Heleen C., Carolyn Fischer, Richard G. Newell, and Takahiro Ueno, "International Technology-Oriented Agreements to Address Climate Change," *Energy Policy*, Vol. 36, No. 1 (2008).

Fischer, Carolyn and Richard G. Newell, "Environmental and Technology Policies for Climate Mitigation," *Journal of Environmental Economics and Management*, Vol. 55, No. 2 (2008).

HSBC, "A Climate for Recovery: The Colour of Stimulus Goes Green," *HSBC Global Research* (2009).

ISI, "ISI Web of Science Database" (2009) [http://isiknowledge.com].

Jaffe, Adam B., Richard G. Newell, and Robert N. Stavins, "Technology Policy for Energy and the Environment," in Adam B. Jaffe, Josh Lerner, and Scott Stern (eds.), *Innovation Policy and the Economy*, Vol. 4 (Cambridge: MIT Press, 2004).

Japan Ministry of the Environment, "The Bill on Amendments of the Climate Change Policy Law" (2002) [http://www.env.go.jp/en/earth/cc/020329.html].

_______, "Law Concerning the Promotion of the Measures to Cope with Global Warming" (1998) [http://www.env.go.jp/en/laws/global/warming.html].

_______, "Air Pollution Control Law" (1996) [http://www.env.go.jp/en/laws/air/air/index.html].

Lee, Shin-wha, "Building Environmental Regimes in Northeast Asia: Progress, Limitations, and Policy Options," in Paul G. Harris (ed.), *International Environmental Cooperation: Politics and Diplomacy in Pacific Asia* (Boulder: University of Colorado Press, 2002).

Ministry of Knowledge Economy (MKE), "Korea Goes for 'Green Growth': Sustainable Development in a Low Carbon Society," edited by Energy and Resources Policy Division, 2008.

Nam, Sangmin, "Ecological Interdependence and Environmental Governance in Northeast Asia: Politics vs. Cooperation," in Paul G. Harris (ed.), *International Environmental Cooperation: Politics and Diplomacy in Pacific Asia* (Boulder: University of Colorado Press, 2002).

Nelson, Richard R., *National Innovation Systems: A Comparative Analysis* (Oxford: Oxford University Press, 1993).

Nelson, Richard R. and Edmund S. Phelps, "Investment in Humans, Technological Diffusion, and Economic Growth," *American Economic Review*, Vol. 56, No. 1/2 (1966).

Nelson, Richard R. and Sidney G. Winter, *An Evolutionary Theory of Economic Change* (Cambridge: Belknap Press of Harvard University Press, 1982).

OECD, *OECD Reviews of Innovation Policy: Korea* (Paris: OECD Publishing, 2009).

_______, *Compedium of Patent Statistics* (2008) [http://www.oecd.org/dataoecd/5/19/37569377.pdf].

_______, *Reviews of National Science and Technology Policy: Republic of Korea* (Paris: OECD Publishing, 1996).

Pempel, T. J., "The Race to Connect East Asia: An Unending Steeplechase," *Asian Economic Policy Review*, Vol. 1, No. 2 (2006).

People's Republic of China Ministry of the Environmental Protection, "Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution" (2008) [http://english.mep.gov.cn/Policies_Regulations/laws/environmental_laws/200710/t20071009_109943.htm].

_______, "The National Eleventh Five-Year Plan for Environmental Protection (2006-2010)" (2008) [http://english.mep.gov.cn/Plans_Reports/11th_five_year_plan/200803/t20080305_119001_2.htm].

Putnam, Robert D., "Diplomacy and Domestic Politics: The Logic of Two-Level Games," *International Organization*, Vol. 42, No. 3 (1988).

Republic of China (Taiwan) Environmental Law Library, "Air Pollution Control Act" (2006) [http://law.epa.gov.tw/en/laws/889404502.html].

_______, "Basic Environment Act" (2002) [http://law.epa.gov.tw/

en/laws/811708521.html].

Republic of China (Taiwan) Executive Yuan, "Taiwan Agenda 21: Vision and Strategies for National Sustainable Development," Approved at the 18th Council Meeting of the Council for National Sustainable Development, Executive Yuan, 2004.

Rongping, Mu, "Innovative Policy for Sustainable Development in China," Paper presented at the AAAS Annual Meeting, Chicago, IL (2009).

Rosenberg, Nathan, *Inside the Black Box: Technology and Economics* (Cambridge: Cambridge University Press, 1982).

Schneider, Malte, Andreas Holzer, and Volker H. Hoffmann, "Understanding the Cdm's Contribution to Technology Transfer," *Energy Policy*, Vol. 36, No. 8 (2008).

Schueller, Margot, Markus Conle, and David Shim, "Innovation Policy under Lee Myung-bak: A Critical Analysis of Governmental Actor's New Division of Labour," Paper presented at the Innovation and Technology in Korea in International Perspective, Wirtschaftskammer Osterreich, Vienna, September 24-25, 2009.

Shapiro, Matthew A., "Targeting and Capturing Returns from Sustainability-Oriented Research," Paper presented at the Beyond Kyoto: Addressing the Challenges of Climate Change, Aarhus, Denmark (2009).

Stavins, Robert N., "Experience with Market-Based Environmental Policy Instruments," in Karl-Goran Maler and Jeffrey R. Vincent (eds.), *Handbook of Environmental Economics, Volume 1 : Environmental Degradation and Institutional Responses* (Amsterdam: Elsevier, 2003).

Stiglitz, Joseph E. and Scott J. Wallsten, "Public-Private Technology Partnerships: Promises and Pitfalls," *American Behavioral Scientist*, Vol. 43, No. 1 (1999).

Stone, Deborah, *Policy Paradox: The Art of Political Decision Making*

*(Revised Edition)* (New York: W.W. Norton & Company, 2001).

UNEP Risoe, "CDM/JI Pipeline Analysis and Database" (2009) [http://www.cdmpipeline.org].

United Nations, *Agenda 21: The United Nations Programme of Action from Rio* (New York: United Nations, 1993).

Wada, Tomoaki, "Recent Developments in S&T Policies after the Lost Decade," Paper presented at the AAAS Annual Meeting, Chicago, IL (2009).

Wallsten, Scott J., "The R&D Boondoggle: Why Is Government Subsidizing Commercially Promising Business Projects?" *Regulation*, Vol. 23, No. 4 (2000).

World Commission on Environment and Development (WCED); *Our Common Future* (New York: Oxford University Press, 1987).