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Regionalism's challenge to the pollution haven hypothesis: a study of Northeast Asia and China*

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Abstract This paper explores the phenomena of environmental coordination within Northeast Asia. I initially frame the discussion around claims that China is a pollution haven for its neighboring countries, and I look for evidence in the domestic and regional environmental institutions which challenge China's pollution haven status. I find that that there is a science and technology-based epistemic community in Northeast Asia which provides an important theoretical response to counter the pollution haven hypothesis. As well, given its strong science and technological output, Japan is poised to assume leadership of the Northeast Asian environmental regime for at least the short- to medium-term.

Keywords epistemic community; regionalism; green R&D; environmental policy; pollution haven hypothesis.

Introduction

Over the past 40 years, and especially over the last 15 to 20 years, we have seen unprecedented efforts to coordinate environmental policies across nations, impacting how we approach two-level games in international negotiations (Barkdull and Harris 2002; and Gallagher 2009). Regional coordination, while less ambitious, should tell a parallel story: fewer players make it easier to address collective action concerns; neighbors are more willing to share intellectual property because of pollution's negative externalities;

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and economic and political relationships between neighbors are strengthened. This has largely been the case for the highly studied European Union (Anderson and Liefferink 1997; Helm and Sprinz 2000; Underdal 1998), where success has been attributed in part to the creation of a European security regime via the Helsinki Act of 1975 and related multilateral institutional arrangements (Brettell 2007).

Transnational interdependence increases the probability of cooperation among states (Keohane and Nye 1989), but environmental regional regimes are not easily created (Keohane and Victor 2011) or understood. For Northeast Asia – the case of interest here – there are confounding factors such as varying levels of pollution, environmental institutions, and capacities and capabilities to deal with pollution. It is acknowledged that regional institutions are nested in the existing, broader international climate change regime (Yoon et al. 2007), but I also claim that the involvement of nation-states beyond the Northeast Asian region kick-started intra-regional co-ordination. What followed was coordinated management from within the region, evidenced by sufficiently funded national environmental agencies, strong regional non-government organizations, and a host of multilateral organizations (Solomon 2007). Most importantly, there has been a region-wide attempt to capitalize on the high-technology base of each state – whatever the level – to improve the environment.

The technology focus distinguishes the Northeast Asian environmental regime from trade and security regimes. Young (1990) makes this clear through his examination of collective action problems surrounding the mitigation (ozone layer depletion, global warming, and biodiversity loss) and the need for concerted action among states.[1] Such action is possible when there are common interests, aversions, and principles among nations,[2] but innovations in technology can also help lower the costs of transitioning from a high to a low greenhouse gas (GHG)-emitting economy. And there is no single innovation method: ideas and technology can be locally generated or imported. They can also be collaboratively generated, and I show here that there is an epistemic community in Northeast Asia in which groups of ecologists within and across borders resist short-term political concerns, inform policymakers, and see beyond the narrow view of opportunity costs of environmental policies (Haas 1990).[3] This community crosses traditional actor and state boundary lines, consisting of scientists and producers of new environmental technologies.

Epistemic community effectiveness in regional environmental regimes is countered by other attempts to reduce transaction costs through international coordination. I specifically refer to the processes outlined in the pollution haven hypothesis as it is described in Taylor (2005): firms target countries abroad for outsourcing and remote production which have lax environmental regulations and can thus lead to reductions in production, labor, and waste costs. There is theoretical research countering the pollution haven hypothesis. Dijkstra et al. (2011) claim that foreign direct investment (FDI) may occur in the presence of strict regulations if it makes

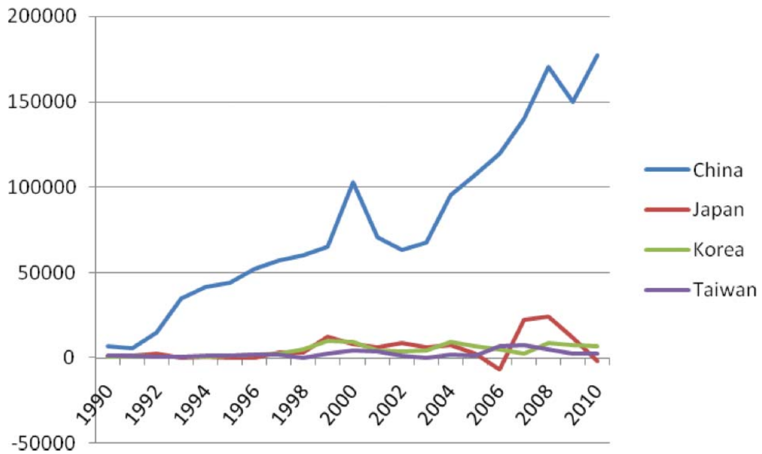

Figure 1 Inward FDI flows, millions of US dollars. Source: UNCTAD (2012).

costs less for a foreign firm relative to pre-existing domestic firms. In this discussion, I highlight China as a pollution haven for several reasons. First, crude descriptions indicate that it is in fact occurring. Foreign direct investment (FDI) flows into China, presented in Figure 1, have been increasing over time and are currently at levels more than seven times those of its neighbors, and all of the Northeast Asian countries are major contributors of FDI to China (Kim and Mah 2006). China has also exhibited exponential growth in the amount of carbon dioxide – a conventional proxy for all GHGs – over the same period, shown in Figure 2. Such growth in carbon

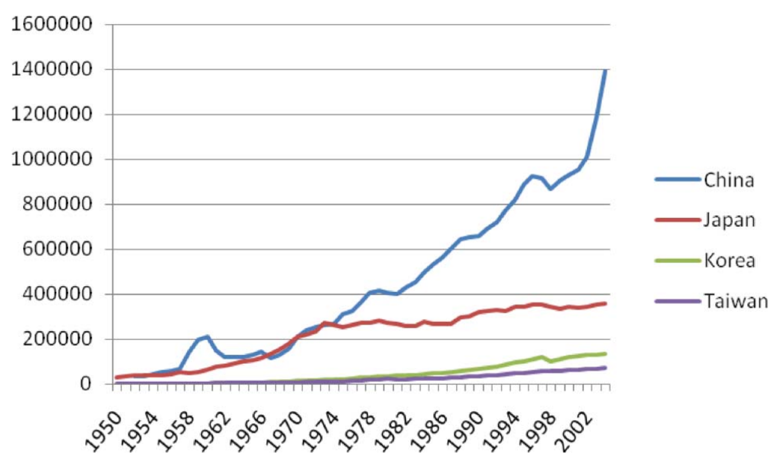

Figure 2 CO2 emissions (mt) in Northeast Asia. Source: OECD (2009).

dioxide emissions is not unexpected given the size of China's population and its steadily increasing appetite for energy since the 1970s.

Epistemic communities can respond to this outsourcing of pollution when it occurs through indigenous application and/or generation of 'environmental technologies'. 'Environmental technologies', in line with OECD (2009), refer to general environmental management, energy generation from renewable and non-fossil sources, combustion technologies with mitigation potential, technologies specific to climate change mitigation, technologies with potential or indirect contributions to emissions mitigation, emissions abatement and fuel efficiency in transportation, and energy efficiency in buildings and lighting. Innovation in pollution control equipment had traditionally been within the purview of the OECD countries (Lanjouw and Mody 1996), but we have witnessed a remarkable increase in the use and generation of environmental technologies in Northeast Asia, China in particular. Consider, for example, the rise in the number of air pollution-related patent applications filed by China in recent years, shown in Figure 3. We can explain this in a number of ways, such as the presence of stricter air pollution regulations in China: stronger regulations attract

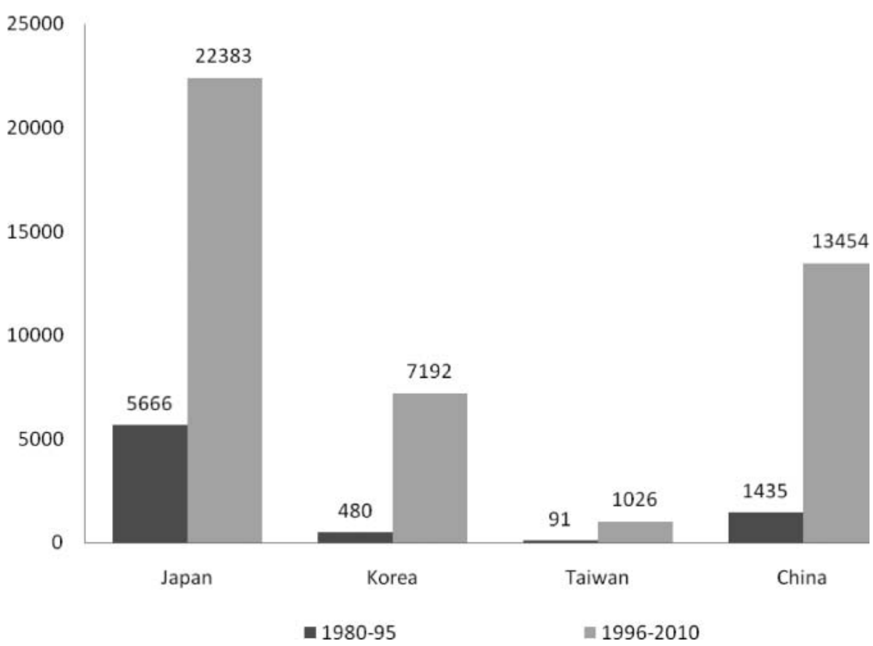

Figure 3 Total number of air pollution-related patent applications, by state. Source: European Patent Office database (http://worldwide.espacenet.com/advancedSearch?locale=en_EP). See Appendix Table A1 in OECD (2009) for details about IPC code classifications for air pollution technologies.

FDI (Kirkpatrick and Shimamoto 2008) which, in turn, generates positive technology transfers (Sun 2011). Transfers along these lines are referenced in the existing literature as confirmation of the pollution halo hypothesis, in contrast to the debilitating effects outlined in the pollution haven hypothesis (Zarsky 1999; Blackman and Wu 1998; Eskeland and Harrison 2003).

The shrewd reader will recognize immediately that the story can be told in other ways, and this gets at the root problems with elegant modeling. Methodologically, we should be concerned that the pollution haven hypothesis does not account for spurious effects, especially for the Chinese case. Some have found evidence in support of it (Zhang and Fu 2008), while others have found that that effects vary according to which pollutants are regulated (Chang 2012) or which provinces are being studied (Di 2007). This is the likely result of incorrect assumptions about the nature of FDI (see Eskeland and Harrison (2003), for elaboration) and the possibility that wage differentials, home market effect, or tariff jumping also contribute to increases in FDI. In China, for example, the effects of FDI are non-linear and have yielded stronger overall regulations (Wilson 2009). Corruption in the host country, as well, might decrease FDI, increase pollution, and be positively affected by lax environmental regulations (as well as lead to lax environmental regulations) (Smarzynska and Wei 2001; Cole et al. 2006). The pollution haven hypothesis also breaks down in China where levels of human capital are high (Lan et al. 2012); yet, human capital can also promote FDI inflows targeting environmental technologies which can, in turn, reduce pollution. Finally, it breaks down in light of conflicting evidence about pollution transfer (in general) from one of China's Northeast Asian neighbors, such as Japan (Elliott and Shimamoto, 2008; Cole et al. 2011). The point here is that the pollution haven hypothesis is overly restrictive in its strict focus on trade-related factors.

There are also historical and other tensions in Northeast Asia which might influence epistemic community building. The East Asian Acid Deposition Monitoring Network's (EANET) attempts to deal with the pollution blowing out of mainland China, for example, challenges several conceptions of national sovereignty. China views the related dust storms as a natural phenomenon regardless of evidence that desertification is anthropogenic. At the same time, Korea has attempted to limit Japan's dominance by protesting against the placement of EANET's network center in Japan. China also hinders transparency attempts by refusing to share large portions of its data (Brettell 2007). These points are useful in explaining the historical development of regionalism, but contemporary motivators such as the pursuit of indigenous technology development, the inward transfer of technology, and real concerns about how these technologies can reduce environmental pollution are the priority here.

Three inter-related goals are set for the remainder of this paper. First, I show through qualitative analysis that China's potential for being Northeast Asia's pollution haven is significantly weakened by a technology focus fostered by domestic and intra-regional environmental efforts. Second, I provide a response to gaps in existing methods which attempt to show causality between FDI and pollution, and I induce a comprehensive alternative to the elegance of the pollution haven hypothesis. Briefly, the pollution haven hypothesis states that regionalism occurs to save costs by polluting abroad; the theory introduced below shows that epistemic community building within the region increases environmental benefits while decreasing environmental costs. Third, I draw attention to the leadership role of Japan in the Northeast Asian environmental regime given its preceding focus on technology and the transfer of such technology within the region.

Outlining domestic and regional efforts

Domestic efforts and potential obstacles

Collective action across the Northeast Asian region is a function of shared interests, so we must first examine the degree to which each country emphasizes environmental protections at home in terms of institutional arrangements. I find a pattern of increased attention to environmental policymaking across Japan, Korea, China, and Taiwan, but there is an overall defensive posture from China. We should not consider China's position a response to inflows of pollution, as its regulations have actually led to increases in FDI (Kirkpatrick and Shimamoto 2008).

Environmental policy data were collected from the Japanese Ministry of Environment, Laws section (http://www.env.go.jp/en/laws/), the Korean Ministry of Environment, Major Policies sections (http://eng.me.go.kr/main.do), the Chinese Ministry of Environmental Protection, Policies and Regulations section (http://english.mep.gov.cn/Policies_Regulations/), and the Taiwanese Environmental Protection Administration, Laws and Regulations section (http://law.epa.gov.tw/en/). Each state's environmental ministry or administrative apparatus has pre-established categories of environmental policies, so I use each state's categorization scheme as the basis for a consolidated set of categories across all four countries.[4]

An analysis of the content of these environmental policies has resulted in the following eight categories: air pollution, broad frameworks, environmental impact statement (EIS)-related, market-oriented, manure/methane-related, recycling-related, internationally focused, and export/import-related. Environmental policies were categorized as air pollution based on whether they targeted emissions of pollutants or polluting factories or plants. These policies often were identifiable by their use of standards for emissions and air quality. Policies were categorized as broad when they sought to address multiple issues. Their breadth is based on efforts to address not a single goal but to serve as a basis for future laws and policies. As such, they are typically the first of all environmental policies. EIS-related policies were identified by whether they discussed the EIS process in terms of development projects, public input, and/or the certification and qualification of those individuals who would be conducting assessments. Policies were coded as market-related if they satisfied one of the following two standards: whether the policy directly targeted or created standards for any products that would have an impact on the market, such as 'green' rated household products, and whether a policy would have some sort of market-related effect, such as standards affecting automobile, coal-fired power plants, or construction. I aggregate all of these categories to generate a composite count of environmental policies for each of the four countries.

From the 1940s to the present, there have been a slew of environmental policies enacted by Japan, Korea, China, and Taiwan. Efforts have been taken in recent years to address certain environmental issues in these four countries, But, while Japan and Korea's policymaking efforts are well represented in the 1990s and 2000s, shown in Figure 4, they pale in comparison to Taiwan and China. This longitudinal trend, while interesting, fails to account for qualitative differences in environmental policies across these four countries. For example, in terms of the policies

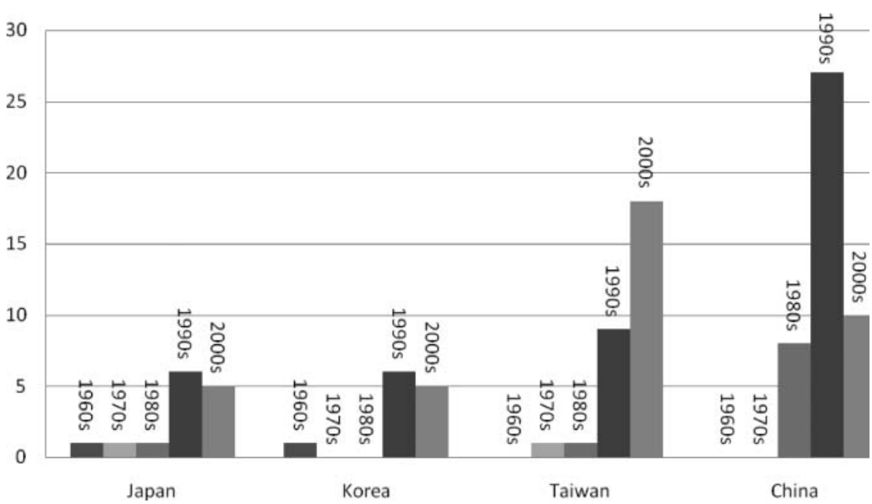

Figure 4 Number of environmental policies and regulations in post-war period. Source: Japanese Ministry of Environment, Laws section (http://www.env.go.jp/en/laws/), the Korean Ministry of Environment, Major Policies sections (http://eng.me.go.kr/main.do), the Taiwanese Environmental Protection Administration, Laws and Regulations section (http://law.epa.gov.tw/en/), and the Chinese Ministry of Environmental Protection, Policies and Regulations section (http://english.mep.gov.cn/Policies_Regulations/). Note: See 'Domestic Efforts' for details about the policy qualification method.

summarized in Figure 4, there are inconsistencies in how each country approaches the regional and international spheres. In Japan and Korea, we observe legislation with broad, extra-regional foci, such as Japan's 'Bill on Amendments of the Climate Change Policy Law' (2002) and Korea's 'Act on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal' (1992). China and Taiwan, however, target the protection of territorial waters (e.g., China's 'Law of the PRC on the Territorial Sea and the Contiguous Zone' (1992) and 'Law on the Exclusive Economic Zone and the Continental Shelf of the PRC' (1998) and Taiwan's 'Major Marine Oil Pollution Emergency Response Plan' (2004)). China and Taiwan also conflate environmental and trade policies under a protectionist umbrella, focusing on import/export concerns related to the environment, such as China's 'Announcement on the List of Toxic Chemicals Severely Restricted on the Import and Export in China' (2005) and Taiwan's 'Management Regulations for the Import, Export, Transit and Transshipment of Waste' (2005). As it will be shown, these are not insurmountable obstacles to regional environmentalism.

Beyond content analysis such as this, I also draw attention to domestic efforts to address environmental pollution through technological advancements. It has been well established that pollution-reducing innovations are a key component of any sort of composite environmental policy (Fischer and Newell 2008; OECD 2009; Jaffe et al. 2003; Jaffe et al. 2004; Johnstone et al. 2010). We can say that the Northeast Asian countries all approach this indirectly through domestic institutions which restrict and/or manage pollution and the generation of pollution-mitigating technologies. Such innovation is ultimately a function of each country's national innovation system (Nelson 1993; Kim and Nelson 2000), meaning that we must account for human capital, research output like patents and publications, and research funding. Each is addressed in the sections which follow.

Regional efforts

Distinguishing domestic from regional environmentalism in Northeast Asia is the explicit emphasis placed in the latter on research, at least from the mid-1980s. This research-based approach offers the greatest challenge to claims that China is the pollution haven for the Northeast Asian countries, as the research itself creates a virtuous cycle: a technology focus leads to more FDI inflows which, in turn, lead to more technological innovation. Pollution subsequently decreases as environmental technologies are applied.

The roots of Northeast Asian environmental regionalism began in 1985 with coordination between the ADB, the UN Environment Program, and the quinquennial state of environment (SOE) reports prepared by the UN Environment and Social Commission for Asia and the Pacific

(UNESCAP). This led in 2010 to the publication of the Asian Environment Outlook (AEO) to provide developing member countries with policy advice and analysis of environmental performance and management. To exchange information with regard to advanced environmental conservation efforts, the Northeast Asian Conference on Environmental Cooperation (NEAC) was initiated by a bilateral symposium attended by Korea and Japan in 1988, growing since then through support and cooperation with the UNEP. Since 1991, the Environment Congress for Asia and the Pacific (ECO ASIA) has targeted information exchange among environmental ministers, focusing expressly on waste management, recycling, and climate change. As well, from 1993, the Northeast Asia Sub-regional Program on Environmental Cooperation (NEASPEC), under UNESCAP, has been focusing on the mitigation of transboundary air pollution from coal-fired power plants, prevention/control dust and sandstorms, and communication about transboundary conservation areas. With regard to air pollution, though, there is a specific emphasis on technology information provision and emissions monitoring and legislation. To bolster capacity building in this regard, the Northeast Asian Training Center for Pollution Reduction in Coal-fired Power Plants and North East Asian Center of Environmental Data Training (NEACEDT) has been established.

The influence of preceding international agreements on regional affairs continued into the mid-1990s. The Temperate East Asia Regional Center (TEA-RC) and its affiliated committee (TEACOM) have been operating under the non-government research organization, SysTem for Analysis, Research and Training (START) since 1995. START is also affiliated with the Asian-Pacific Network for Global Change Research (APN), which represents the starting point for a Northeast Asian environmental regime with an explicit technology focus. Initiated through the 1990 White House Conference on Science and Economics Research Related to Global Change, APN was formally launched in 1996. Since then, it has provided grants for scientific research projects related to global change research with, for the 2008–09 period, 65 percent of funding ($1.27 million) originating from Japanese government organizations, 25 percent ($480,000) from the US National Science Foundation, and the remainder largely from reserves. Roughly 60 percent of these funds goes toward research grants which always engage multiple countries in the Asian-Pacific region (APN 2010).

From 1998, regional efforts have also arisen from within. The East Asian Acid Deposition Monitoring Network (EANET), mentioned already in the Introduction, has been functioning as the 'core of an emerging acid rain regime' (Brettell 2007: 95), with a broad regional affiliation. From the following year, the Asia Development Bank-Global Environment Facility (ADB-GEF) was established, focusing on efforts by the ADB to apply for grant approval by the GEF for projects which address environmental issues, including climate change. Related efforts between the ADB and other international agencies include the Asian Environmental Compliance and Enforcement Network (AECEN) from 2005 to strengthen environmental laws within the region (Korea and Taiwan do not participate). Also from 1999, the Tripartite Environment Ministries Meeting (TEMM) has dealt with environmental pollution and environmental degradation among Japan, Korea, and China. TEMM presents a sense of collective responsibility and, thus, emphasizes the need for information exchange and strengthened cooperation in environmental research. TEMM also attempts to formalize environmental education across Japan, Korea, and China. These efforts have led in part to domestic legislation, such as Japan's 'Law for Enhancing Motivation on Environmental Conservation and Promoting of Environmental Education' (2003) and the Korean 'Act on Promotion of the Purchase of Environment-Friendly Products' (2004), which affects consumers' decisions and preferences over time.

The Kyoto Protocol, despite its drawn-out implementation process, represented a turning point for cross-national attempts to deal with GHG emissions. The Clean Development Mechanism (CDM), in particular, has the potential to be a major force in integrating technology and environmental policies, allowing source countries to invest in GHG-reducing ventures in other countries and thus decrease costs for their own GHG emissions. Based on their membership in the UN, Japan, Korea, China, and Taiwan (although Taiwan was formally replaced by mainland China in 1971) are involved in the CDM. 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). Among these 1,682 projects, 239 (14.2 percent) are initiated out of Japan (OECD 2009). Yet, the CDM is limited by the market-based constraints of the spot market to sell climate credits and the market to produce energy at a cost-effective level (Schneider et al., 2008; World Bank 2010). There is also no distinction offered between non-CDM participants such as Taiwan. If SMEs – a significant industrial structure in Taiwan – are indeed more likely to share vital information with developing countries (Marcotte and Niosi 2005), the CDM model would neglect one of China's most important neighbors.

While the CDM incorporates an extra-regional element, the greatest potential for the East Asian countries to establish GHG-related connections within the region lies in the Asia Pacific Partnership on Clean Development and Climate (APPCDC). This voluntary partnership involves Australia, Canada, China, Japan, Korea, and the US, with a goal of developing key technologies without the complexities of CDM's multilateralism (Kellow 2006; Van Asselt et al. 2009; Kellow 2009). It is also likely that the APPCDC emerged both in response to the US's lack of support for the Kyoto Protocol as well as the support from countries within Northeast Asia (Karlsson-Vinkhuyzen and van Asselt 2009). Whatever the reason, the simple fact that the APPCDC is a technology-oriented agreement (TOA) rather than an agreement like the CDM, which is rooted in market incentives to reduce GHGs (e.g., spot market-based prices for climate credits), reduces its chance of failure (De Coninck et al. 2008). It is, as Schneider et al. (2008) claim, embedded in local institutions, thus creating greater stakes and commitments for the participating countries.

Regionalism and environmental technology

International and regional agreements

Backing into a theoretical response to the pollution haven hypothesis, I begin by making connections between the various efforts described above. Northeast Asian environmental agreements are rooted in international environmental coordination efforts. Their origins were the 1965 UN Development Program, which helped distribute funds and support in the interests of biological diversity and global warming, and the 1972 UN Environmental Program created by the Stockholm Conference, which oversaw cross-national environmental concerns and monitored 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. We can also examine multinational efforts to address sustainable development along two parallel axes: sustainable development and climate change mitigation, the former 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 (World Commission on Environment and Development, 1987).

Sustainable development at the multinational level attempts to affect economic disparities at the national and international levels, health concerns, and environmental degradation. These concerns were initially addressed through the Brundtland Report (1987) and calls for a UN Conference on Environment and Development (UNCED), which eventually resulted in the adoption of Agenda 21 (1992) by 178 countries at the Rio UNCED. The Millennium Development Goals (MDGs) (2000) further institutionalized and built upon Agenda 21, as did the Johannesburg Plan of Implementation (2002), which represented the tenth anniversary of the summit in Rio. From 2005, the Kyoto Protocol to the United Nations Framework Convention on Climate Change was officially implemented, although GHGs emissions were addressed at the 1997 meeting. The Kyoto Protocol is distinct from the MDGs, as it expressly focuses on reductions in GHGs by industrialized countries. Discussions about GHG reductions continued at the Conference of Parties (COP) 13 of the United Nations Framework Convention on Climate Change (UNFCCC) in Bali in 2007, the G8 Summit held in 2008 in Japan, the COP 15 meeting held in December 2009 in Copenhagen, and all subsequent COP meetings.

Reflecting on the previous discussion and looking at the development of international and regional efforts over time, regional agreements appear to have two origins. Presented graphically in Figure 5, some are rooted in

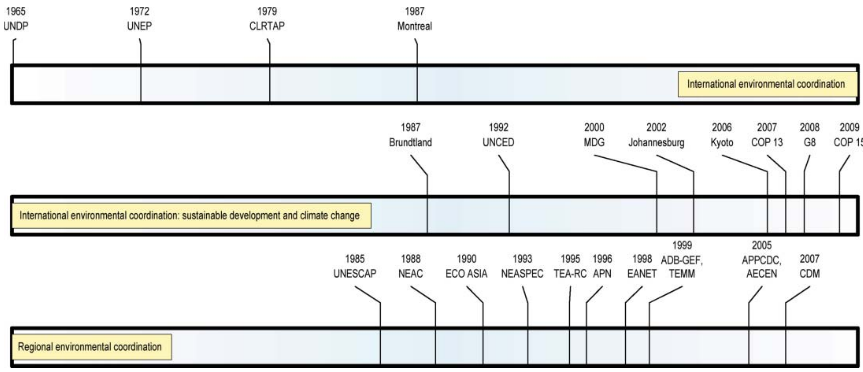

Figure 5 Key multinational and regional environmental policies and events: 1965–2010.

preceding international agreements, such as UNESCAP, NEASPEC, ECO ASIA, TEA-RC, APN, ADB-GEF, and the CDM. The remainder originates from local efforts, such as NEAC, EANET, TEMM, APPCDC, and AECEN. These are largely attempts to increase cross-state environmental dialogue, both within the region (e.g., through NEAC, EANET, or AECEN) or super-regionally (e.g., through the ADB-GEF).[5]

We also observe that, particularly from the mid-1990s, there is a prevalent focus on technological coordination across the region, represented by NEASPEC, TEA-RC, APN, APPCDC, and CDM. These originate in broader multilateral efforts (e.g., NEASPEC, which is from the UN), APN (via the 1990 White House Conference on Science and Economics Research Related to Global Change), and the CDM (from the UN). This technological orientation is also accompanied by the necessary capital to support international collaboration, research, and product development. TOAs, thus, typically involve large investments and, thus, strong expectations that tangible outcomes will result: publications, patents, new or improved products, and, most importantly, a less polluted environment. We are now poised to present a model which shows exactly how TOAs are tied to regional efforts and embedded in local institutions.

Accounting for hypotheses of pollution haven and epistemic community building

Given the nature of international agreements described above, particularly those rooted in UN mandates and agreements, and given the remaining ambiguity about their connections to domestic and regional efforts, I present a model of epistemic community building in Figure 6. What is apparent is that region-based institutions are equally if not more important than international institutions which mandate reductions in pollution, etc. In this

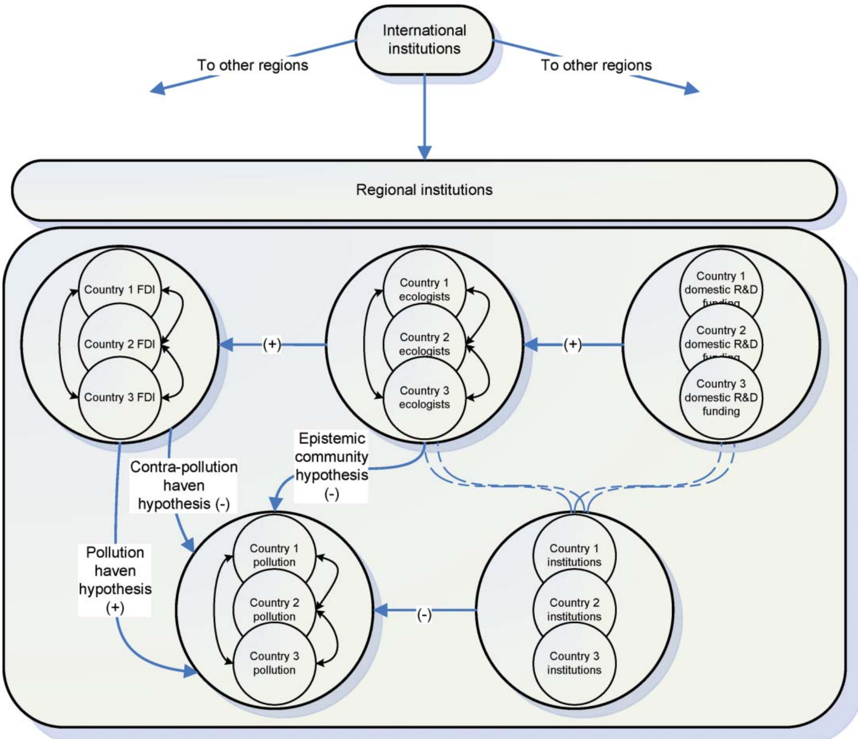

Figure 6 Accounting for hypotheses of pollution haven and epistemic community building.

way, the model below further advances our understanding of transnational interdependence (e.g., Keohane and Nye 1989), refutes claims of the primacy of the international climate change regime over all else (e.g., Yoon et al. 2007), and clarifies misunderstandings of how and why cross-national epistemic communities arise with regard to environmental pollution (Haas 1990).

The expected relationships between regional attributes are measured largely as collections of the regional constituents' institutions and attributes. Starting at the far left of Figure 6, we can identify the familiar pollution haven hypothesis, as FDI flowing to and from countries in the region is expected to result in increased pollution for receiving countries in the region. Pollution is not constrained by political borders, though, illustrated by the inter-country pollution flows for all regional constituents. The countering effect to the pollution haven hypothesis is represented by evidence that there are reductions in pollution when FDI targets areas with high levels of human capital (Lan et al. 2012), when certain pollutants are regulated (Chang 2012), or when certain provinces are studied (Di 2007).

The epistemic community also results in reductions in pollution as ecologists, scientists, engineers, etc. from the region's constituent countries collaborate. The arrows between the ecologists in countries 1, 2, and 3 in Figure 6, thus, do not necessarily represent physical transfers of ecologists between countries so much as the knowledge flows, technology transfers, and collaborative efforts among each country's ecologists. Working together in ways consistent with the region-based agreements for Northeast Asia, this collaboration reduces pollution through the implementation of new technologies. Cross-national collaboration is most strongly impacted through TOAs and other agreements which address each country's domestic institutions as well its research output. Moving further to the right in Figure 6, domestic funding for 'green' research is expected to positively affect, respectively, each country's quality and quantity of ecologists. Northeast Asia exhibits clear evidence of this research emphasis (Shapiro 2009).

Output and implications

We observe that the environmental focus reflected in intra-regional research collaboration is led by Japan. With regard to all environmental technologies, Japan – one of the top three most-technology transferring states in the world – is the principal source of environmental technology in Northeast Asia. China is the second-most frequent recipient of Japanese environmental technologies with 1,978 duplicate patent filings (i.e., the applicant filed in both the source state and the recipient state) of air, water, and waste patents, Korea the third-most with 1,671 patents, and Taiwan the fifth-most with 685 patents. Extra-regional states also play a role in transferring such technologies to Northeast Asia: Japan has received 1,355 environmental patents from the US and 1,299 from Germany, while China has received 1,072 from the US and 750 from Germany (OECD 2009). Nonetheless, over the last decade or so, geography and a converging technological focus in Northeast Asia have dictated opportunities for within-region research collaboration in terms of general (i.e., not solely environmentally-related) publications. This basic research is likely to result in applied technologies (Nelson 1959; Rosenberg 1990), although we do not yet know how much or to what extent it is manifested in environmental technologies. Presented in Table 1, each of the four Northeast Asian states has the remaining three listed among its most frequent publication partners.

All of this shows a strong pattern of environmental technology transfer within Northeast Asia – most pronounced in technology outflows from Japan to its neighbors – and a revealed preference for collaborating with one's neighbors in general. There are also correlations with the increase in indigenous air pollution technologies, presented in Figure 3, which show marked increases in the number of patent applications over the last 30 years: nearly a four-fold increase in Japan, a 15-fold increase in Korea, a nine-fold increase in China, and an 11-fold increase in Taiwan. What we

Table 1 Indexes of internationally co-authored S&E articles, by selected state pairs: 1998 and 2008

Partner rank	1998 Japan	2008 Japan	1998 Korea	2008 Korea	1998 Taiwan	2008 Taiwan	1998 China	2008 China
1st	Korea	Korea	Taiwan	India	Singapore	India	Singapore	Singapore
2nd	China	Taiwan	Japan	Japan	China	China	Taiwan	Taiwan
3rd	Taiwan	China	China	Taiwan	Korea	Singapore	Korea	Japan
4th	US	India	India	US	India	Japan	Japan	Korea
5th	India	Russia	US	China	US	Korea	Australia	Australia

Source: Thomson Reuters, Science Citation Index (SCI) and Social Science Citation Index (SSCI), from National Science Foundation (2010).
Note: Article counts from SCI and SSCI based on institutional addresses listed on article.

observe, thus, is a tightly knit, TOA-driven environmental regime in Northeast Asia which has seemingly addressed the largely environmental coordination problems through research collaboration and a focus on technology transfer.

Future Prospects

For China and other developing countries which benefit from inflows of technology to treat environmental degradation, additional institutions should be identified and analyzed. I am particularly interested in the fostering and encouragement of intellectual property rights (IPRs) in China. These are likely to bolster inflows of technology even more than simply sending aid to China (Ueno 2009), which is the general structure of the CDM. Tied to this are the challenges China faces in limiting its pollution haven status while simultaneously pursuing rapid economic growth. In China – and all rapidly developing countries, for that matter – we must simultaneously consider environmental protection efforts and economic reforms. They were last addressed at the policy level during Deng's post-1992 economic reforms (Jahiel 1997). The story has gotten much more complicated since then, requiring an account for the relationships between the market, civil society, and the state in the context of openness to other countries (Carter and Mol 2007; Sonnenfeld 2006; Mol and Carter 2006) or between environmental non-governmental organizations and environmental policymaking (Shapiro and Gottschall 2011). All or any of this would inject important institutions into the model induced above.

Finally, while my claim and conclusion has been to challenge the elegance of the pollution haven hypothesis as it applies to China, we can build on the existing research with two areas of improvement. First, given China's relatively high regulations, we should acknowledge and research the possibility that lax enforcement and corruption affect pollution inflows. In ways consistent with Smarzynska and Wei (2001) and Cole et al. (2006), I suggest this be done in terms of region-specific FDI transfers. Second, with regard Kirkpatrick and Shimamoto (2008), we must engage in quantitative analysis of FDI by sector and country source. The hypothesis would be, essentially, that FDI is a function of domestic environmental regulations; yet, environmental technology (flows or stock) are also a function of FDI. This two-stage approach is complicated and would require the appropriate identification of instruments for FDI. Yet, it would at least control for exactly the sorts of spurious effects that seem to plague the pollution haven hypothesis.

Conclusion

We have entered a new era of environmental regimes in which geographic concerns and epistemic communities help establish long-term goals which typically have been difficult to reach because of collective action problems. While the above analysis has not established a causal connection but seeks to induce a theory of Northeast Asian epistemic community building, one might say that even more is unresolved than when we started. But, that is not true, as the correlation between high levels of bilateral transfers, internationally co-authored science and engineering articles, and the growth in air pollution-related patent applications indicates that the pollution haven hypothesis is based on much too elegant a theory. A firm's decision to invest in a country with lax environmental laws – the evidence of which is still not wholly conclusive in terms of China's relationships with its neighbors – is mediated by the knowledge base and technology orientation of the pollution-receiving country. Germany and the US may lead the charge in terms of select environmental technology projects in China (e.g., via the CDM), but the largest bilateral transfers to Northeast Asia via duplicate patent filings in the patent source state and the recipient state are from within the region.

Similarly, while international agreements have preceded Northeast Asian regional coordination efforts, the latter of which were originally designed to increase environmental policy dialogue among the Northeast Asian region's states, these dialogue-building efforts have been superseded by environmental technology coordination. And such coordination is consistent with the high-technology capabilities of these four states and the development of epistemic communities in environmental regimes. These are also positively correlated with the rise in domestic environmental policies in these four states. In conjunction, they provide strong countermeasures to and evidence against China's pollution haven status.

Notes

1 The establishment of the regime for protection of the ozone layer was the initial force generating interest in the study of international environmental regimes, such as the 1985 Vienna Convention, the 1987 Montreal Protocol, and the 1990 amendments to the Montreal Protocol. Young (1990) points out that, although environmental regime formation is predominantly established in the framework of conventions and protocols, there are also cases in which environmental regimes are constituted in initial agreements, such as the 1946 International Convention for the Regulation of Whaling, and the 1973 and 1978 MARPOL Convention for the Prevention of Pollution from Ships. More recently, Breitmeirer et al. (2006) created a database based on the responses of experts on 23 environmental regimes to examine the process of regime creation and efficacy. These mirror our concerns here, yet Breitmeirer et al. (2006) conflate case selection and limit coverage of greenhouse gas emissions from 1992 to 1998. To some extent, these are addressed qualitatively by Biermann and Siebenhuner's (2009) treatment of international bureaucracies, such as the OECD, World Bank, and UNEP. Excluded, however, is the role of international technology transfer as a component of international environmental regimes.

2 We can model participation in regimes with a utility function which embodies a sense of general obligation, consistent with Jervis's (1982) claim that

short-term interests are sacrificed given expectations of reciprocation sometime in the future. Behavior, thus, is infused with principles and norms, which is the distinguishing characteristic of regime-governed activity vis-à-vis narrow calculations of interest (Krasner 1982). When nations choose to forgo independent decision making, dilemmas of common interests and common aversions arise (Stein 1982). In order to reach a Pareto-optimal outcome in the face of these dilemmas, all players must ignore their dominant strategies.

3 The backdrop to the 1987 Montreal Protocol provides an excellent example of how an epistemic community of ecologists may affect international cooperation. In the few years prior to 1987, there were several studies which indicated that international controls on chlorofluorocarbons (CFCs) were necessary to protect the ozone layer. Loaded with this information, a transnational epistemic community of atmospheric scientists took steps to influence the positions of the UNEP and the United States. This information, however, was not necessarily certain, calling for anticipatory action (Haas 1990). In this case, the common belief and desire of environmental protection superseded the scientific method.

4 For example, in Japan, policies are categorized as follows: global environment; waste and recycling; air and transportation; waste, soil, and ground environment; health and chemicals; and nature and parks. The following categories are used in Korea: green growth; environment, economy, and society; water quality and water ecosystem; water supply, sewerage, soil and groundwater; air and climate change; wastes and recycling; health/chemicals; nature and parks; and international cooperation. In Taiwan, the policies are divided into the following categories: basic and organic; soil and groundwater pollution; water and marine; waste; atmospheric pollution; EIS; toxics management; environmental disputes; and other laws and regulations. Finally, in China, policies were divided as follows: framework provisions; prevention and control of water pollution; prevention and control of air pollution; solid wastes management; noise and vibration management; hazardous chemicals management; EIS; pollution discharge and levying. For certain categories, this is a relatively simple process: Japan's 'waste and recycling' policies, Korea's 'wastes and recycling' policies, Taiwan's 'waste' policies, and China's 'solid wastes management' policies can be initially grouped together. Other groupings across all four countries are also possible, such as, Japan's 'air and transportation' policies, Korea's 'air and climate change' policies, Taiwan's 'atmospheric pollution' policies, and China's 'prevention and control of air pollution' policies. However, for other categories, close matches are possible initially for only a couple of countries: Japan's 'global environment' policies with Korea's 'international cooperation', for example, or Taiwan's 'EIS' policies with China's 'EIS' policies. There are also a number of categories which are unique to particular countries, such as Japan's 'health and chemicals' policies, Korea's 'green growth' policies, Taiwan's 'environmental disputes' policies, and China's 'noise and vibration management' policies.

5 There are exceptions, such as ECO ASIA and TEMM. This is likely due to ECO ASIA's former's close coordination with USAID and TEMM's focus on conveying news and updates to intra-regional talks.

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