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Science diplomacy at the intersection of S&T policies and foreign affairs: toward a typology of national approaches

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In the wake of burgeoning international activities and collaborative venues in S&T, rich industrial countries have taken to science diplomacy to strengthen their innovative capacities or to foster cross-border civil relations. Apart from some theoretical considerations and empirical case studies, however, we still know little about its different objectives or the strategies, administrative procedures and resources deployed at this fuzzy intersection of S&T policy and foreign affairs. Presenting findings of a comparative study of six countries' science diplomacy, this article puts forward some simple heuristics to account for different programmatic styles and organizational patterns in this emerging field.

NOWADAYS IT IS widely acknowledged that science, technology and international affairs affect one another, bearing pervasive mutual influences. It goes without saying that globalization has considerably enhanced and extended the importance of science and technology (S&T) for and in international relations (IR) beyond their traditional domains. National policy-making, for instance, today can no longer afford to ignore S&T developments and activities abroad, especially not those of rivaling countries. At the same time, S&T issues underpin many concurrent global challenges while scientific collaboration clearly bears upon social capital and trust-building badly needed to nourish civil relations between different and above all adversarial countries or cultures. No wonder, then, that S&T somehow or other have found their way into the foreign policy of numerous leading industrial countries.

Notwithstanding their different objectives and dynamics, S&T have gained grounds in IR, both as an issue in its own right as well as a tool for 'science diplomacy' (SD). Apart from strengthening a nation's knowledge and innovation base, international scientific cooperation comes to be seen as an effective agent to manage conflicts, improve global understanding, lay grounds for mutual respect and contribute to capacity-building in deprived world regions. All in all it has become subject to policy initiatives around the world, though its scope and objectives, instruments and intensity differ widely.

The ongoing de-nationalization of scientific research (Wagner and Leydesdorff, 2005),[1] economic globalization, and growing international competition on all markets for goods and services keep extending the playing fields of IR. S&T have gained an important and ever-increasing role in the competitive quarrel for market shares, power, and influence (Skolnikoff, 1993; Wagner, 2002).

The more a nation's prosperity and economic success hinge on its ability to tap into global resources and to attract talent, capital, support and admiration, the better it is advised to look for strategies to use its R&D assets most effectively to secure competitive advantages. At the same time, global phenomena such as climate change, infectious diseases, famines, migration, nuclear non-proliferation or terrorism call for international collaboration in S&T to tackle, or at least to ease, the many multi-faceted problems they raise or entail. The controversial Intergovernmental Panel on Climate Change is an important example for this new kind of global approach and science

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policy, the less prominent Global Science Forum of the OECD just another.

In addition, with cultural and political tensions mounting all over the world, conventional diplomacy, military power, and political or economic coercion have lost their former grip in IR. Today, attraction, credibility and performance count more for a country's international standing than its mere power, or at least so it seems: 'smart power' is on the rise, and so is the demand for SD. Academic exchange programs, for instance, may help bridge the participants' different outlooks, resources, commitments, serve all parties involved and build valuable transnational social capital. As a matter of fact, more and more countries are up to incorporate S&T in their diplomatic toolkits in order to buttress their IR with ties to civil society, especially in those regions in which official relations are somewhat tainted. Hence it looks as if SD will be more than just a fad. Rather, it needs to be understood as a serious challenge both for international conflict management and foreign policy as well as an important extension, and additional resource, of a nation's science policy.

Ten years ago, many countries had started to worry about their relative performance in R&D and international competitiveness. Yet only a few were ready to deliberately address and engage S&T issues in their foreign policy (Edler and Boekholt, 2001) and to prepare for what might become a global 'war on talents' and scientific resources. Since then, international S&T programs and activities have surged and made inroads in IR. SD has become a proxy for both the use of science for diplomacy and of diplomacy for science, that is, for the enhancement of scientific research and innovation capacities by way of international collaboration with mutual benefits.

Attempting to surf the tide, many nations have recently geared up their diplomatic staff and programs dealing with S&T collaboration or global issues, in some cases even with a big fanfare: In 2000, for instance, the UK launched a spectacular cross-departmental Agenda for Global Change, and set up a Science and Innovation Network with numerous outposts abroad as its agent or operative wing meant to remodel, expand, and replace the Foreign Office's former science counselors' network. Also in 2000, the USA created the new position of an S&T Advisor to their State Department.

Other nations followed suit in discovering S&T for their foreign policy or in launching new collaborative programs. In its four-year plan for Education, Research, and Innovation 2008-2011, Switzerland, a small country whose prosperity and outstanding competitiveness[2] are heavily based on a strong knowledge economy, for the first time provided for joint S&T programs with researchers and companies from 'target regions' outside of Europe and the USA, and the Swiss foreign service should help path their way. In April 2008, Japan's high-ranking Council for Science and Technology Policy passed a memorandum, Toward the Reinforcement of Science and Technology Diplomacy[3] that highlighted the capitalization of S&T as an emerging field of IR in which 'soft power' would play an ever bigger role (Yakushiji, 2009). Similarly, the German Federal Government touted an *Internationalisierungsstrategie* to bolster the 'High-Tech Strategy' it had enacted two years earlier while the Foreign Ministry staged a new initiative on foreign science policy early in 2009.[4] Last but not least, in February 2008 the National Science Board issued a policy paper under the pressing heading, International Science and Engineering Partnerships: a Priority for US Foreign Policy. There it argued that the government's continued neglect of S&T in foreign policy and the excessive curbs it had imposed on academic exchanges in the wake of 9/11 would thwart and eventually squander the country's scientific excellence, global pole position in S&T, and innovation base.[5] Concomitantly, the reputable, and politically powerful, American Association for the Advancement of Science (AAAS) founded a Center for Science Diplomacy (CSD) in the fall of 2008 to advance:

> the over-arching goal of using science and scientific cooperation to promote international understanding and prosperity … by providing a forum for scientists, policy analysts and policymakers through which they can share information and explore collaborative opportunities.[6]

S&T policies even became a subject of supranational governance. In the multi-layered governance system of the European Union stipulated by the Maastricht Treaty of 1992, R&D, though primarily remaining under the responsibility of the individual member states, are defined as a domain for common activities and programs that have received lavish funding. The European Commission (EC) has shown an inclination to engage S&T in its foreign policy and deployed a small number of S&T counselors in the European Union's missions abroad. However, these are neither in charge of large collaborative programs nor prepared or encouraged to pursue SD in a more narrow sense. Rather, it is their job to promote the EC's Research Framework Programs and the concept of the European Research Area as beacons for security and prosperity by the way of transnational cooperation and integrating resources in R&D. Yet the EU also tries to woo foreign investment, and partners, for expensive large-scale research facilities.[7] When it stages political dialogues and partnerships with non-member states to address topics of cross-border reach such as climate change, sustainable energy, health, support for capacity-building through infrastructure and training programs (Stein, 2002b; Stein and Ahmed, 2007; EC, 2008), this is as close to SD as it can get.

This great variety of policy approaches and activities reflects the fuzzy character of any SD: the field engages not just one or two, but a large number of different organizational actors, government and non-governmental organizations, as well as private companies. Neither its borders nor the rules of the game are well-defined. There is no recipe for what works best or what does not since the approaches, programs, and tools which individual countries resort to mirror the idiosyncrasies of their institutional and political culture that also shape their domestic science policies (Lederman, 1987). Ultimately, this individual 'framing' determines what is feasible and what is not. Anything goes, but not anywhere. A country's options to embark on international S&T and SD are limited. Most of them command only weak capacities to effectively coordinate the different policies and activities involved (Braun, 2008; Wagner, 2002). It is evident, though, that the traditional foreign service is neither well-prepared nor ready to shoulder the complex and delicate new tasks of SD.

Research objectives and methods

In this article we want to sketch out how six important players pursue their interests and do business in SD. To get a better understanding of what is going on in this emerging policy field, we examined the respective objectives, priorities, programs and resources of France, Germany, Japan, Switzerland, the UK and the USA as 'competitors' with respect to commonly embattled 'target markets' in the BRIC states (Brazil, Russia, India and China), South Korea, and the USA itself. Taking it for granted that SD has wangled its way into foreign policy we looked for a heuristics for cross-national comparisons and for a cursory typology to tell their different approaches apart. While the EU has turned out to be only marginal for the focus our study, we nevertheless interviewed their delegation staff members in the target countries to weigh on both the member states' and the EC's activities on the ground to spur S&T collaboration and to capitalize on R&D for better IR. Not least we tried to find out to what extent, if at all, the EU counselors' work was geared to that of the science attachés of the member states' (in particular Germany, France and the UK).

Trying to find out why, to what an end, and how the six 'competitor' countries engage in SD, what characterizes their individual approaches and if these share some common ground, we studied published papers and semi-official documents from national governments and S&T agencies to get a grasp of what they are primarily after in their SD and what characterizes the institutional setting relevant to that field. The bulk and backbone of our data, however, derived from more than 80 semi-structured expert interviews with science counselors or secretaries at the six countries' embassies and with liaison officers or representatives of S&T agencies in our 'target regions'. These interviews took place in Beijing, Boston, Brasilia, Moscow, New Delhi, New York, Sao Paulo, Seoul, and Washington DC between September 2008 and February 2009. In addition, we led in-depth talks with senior officials from German ministries in Berlin and Bonn, from the US Department of State, the National Science Foundation, the National Institutes of Health and the AAAS in Washington DC and from the German Research Foundation (DFG) in Bonn, that is at the home base of those agencies and ministries that actively pursue SD. At the end of February 2009 we discussed some of our preliminary findings at a one-day workshop with science attachés and government officials from the other five competitor countries based in Berlin to double-check and hone our conclusions.[8]

Science and technology and international relations — a long intriguing affair

S&T have played an important, even if somewhat concealed role in IR for quite some time already.

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Immediately after World War II, due to the salient rise of 'big science' with costly large-scale projects and the looming threats of the atomic bombs, they gained hitherto unparalleled political attention. For the sake of cost-sharing, a number of important projects, programs and facilities run by international consortia were launched, and it was up to diplomacy to look after the implementation of legal treaties and framework conditions such as intellectual property rights or social and employment issues with regard of staff working abroad.

But SD became also pivotal, though inconspicuously, to ease tensions and promote some rapprochement between the Communist block and the Western world at the heights of the Cold War,[9] starting with the Baruch Plan of 1946 to internationalize the control of nuclear energy, continuing with the famous speech, Atoms for Peace. that US President Dwight D Eisenhower gave at the United Nations' General Assembly in 1953 up to scientific exchanges as icebreakers between the USA and China that paved the way for more friendly relations between the two countries. In 1955, Albert Einstein and Bertrand Russell called upon eminent physicists from the Soviet Union and all over the world to join a conference in the Canadian village of Pugwash in 1957 to discuss the threats of thermonuclear warfare. While the Pugwash-Movement may count as the first non-state SD, the US and other governments eventually launched a number of other projects to engage the scientific community to alleviate tensions, contain the risks of armed conflicts, bridge ideological gaps, build trust, and stir civil relations by way of scientific collaboration as a 'diplomacy of deeds', as the AAAS' CSD puts it trenchantly on its website.

S&T also played a crucial part in one the most important peace projects of the 20th century: the formation of the EC that has now become an EU (Guzzetti, 1995). Tying economic and political integration to trans- and supranational S&T looked like a silver bullet that could help Europe to protect itself against Soviet expansionism, to foster economic and political collaboration, and at the same time take on what appeared to be the 'American challenge'. In fact, S&T cooperation became an asset on the European road toward prosperity and security. Spilling over from catering for demands of the scientific community in the first place on a case-by-case basis (Stein, 2002b) to boosting technology and innovation (Borrás, 2003), however, it has again become susceptible to national antagonisms and demands for equity or fair economic returns (Dienel *et al*, 2002). Still, the EU prides itself on S&T as a pillar of integration. Hence it is more than willing to engage R&D in its foreign policy to cope with global cross-border problems and for capacity-building projects in the Southern Hemisphere (Stein and Ahmed, 2007; Engels and Ruschenburg, 2008).

After the Communist bloc had collapsed, the demise of nuclear, biological, chemical and radiological weapons production in the former Soviet Union spurred widespread fears now unemployed scientists and technicians could be lured to sell their expertise to rogue states and terrorist groups around the world (Klein, 2001). That triggered what may be called a new chapter of SD. Initiatives — such as the International Science and Technology Center, established 1992 as an intergovernmental organization by agreement between the EU, Japan, the Russian Federation, and the USA to 'redirect … talents to peaceful activities',[10] or the US Civilian Research and Development Foundation (CRDF), created by legislation in 1991/93 and endowed by the US Congress since 1995 — were designed to:

> help ex-Soviet scientists and engineers weather the funding crisis created by the USSR's collapse, so as to staunch 'brain-drain', prevent proliferation of weapons technologies, and create mutually beneficial business opportunities.[11]

The thrust and mission of these new organizations was to help newly independent but economically and politically weak states with capacity-building in S&T, and at the same time promote and spread Western political values through unrestricted, uncensored academic work and scientific standards. Non-governmental organizations have started similar projects, even if on a very different scale, in conflict-ridden regions of the Middle East and sub-Saharan Africa. In the meantime, the CRDF has considerably expanded its regional and programmatic stretch to now more than 40 countries. Interestingly enough, these initiatives, let alone 'core-issues' of international collaboration in S&T, still have not made it into the purviews of the US Foreign Service. Its ranks still tend to regard SD and S&T as a mantle for multi-purpose, highly diverse programs and activities of mostly marginal importance and impact with no common denominator.

So far, S&T have also caught only little attention among 'traditional' scholars of IR. Just a few have explicitly dealt with their role and contribution to international affairs, yet mostly from a theoretical bird's-eye view (Rosenau, 1990; Skolnikoff, 1993) rather than in empirical case studies (Chung, 2002; Dufour, 2002; Stein and Ahmed, 2007; Engels and Ruschenburg, 2008; De Conninck *et al*, 2008). This blank may have to do with the fact that the IR and S&T communities both apply very different interests, mind-frames, and methods to their studies which are difficult to reconcile (Haas, 1992; Stein, 2002a). S&T do not fit well into common theoretical frameworks of IR, even though — or maybe just because — they may be employed by neo-realist, neoliberal institutionalist or constructivist approaches alike (Weiss, 2005).

Many key concepts and terms that characterize our field of investigation, such as globalization, innovation, science *and* technology, are still not well understood or widely agreed upon. As long as the role of

S&T in foreign policy and international development is not much better investigated and understood than is the case today, one thus needs to caution against all kinds of blanket-judgments. In a nutshell, we do not have enough data, validated knowledge, and captivating concepts to fully understand the patterns and potentials of international S&T collaboration and the problems coming along with them.

This is equally true for SD. Science's epistemic peculiarities no doubt limit the potential use and leverage of S&T for political purposes. While governments take them to be just means to pursue external political or economic goals, the scientific community, research agencies and research institutions are attracted and motivated to engage in collaborative projects by the prospects of gaining additional leverage, secure funding and support for their own endeavors but not serving national objectives. That said, for the time being even the most ardent advocates for SD as a panacea for conflict-prevention and international capacity-building cannot but resort to lofty promises with little evidence and hard facts to back their claims. Many, if not most, may turn out to be lemons. However, until now, we cannot tell one approach from another.

Science diplomacy's objectives and rationales

Seen from a bird's-eye view, both international S&T policies and SD pursue a whole range of different motives and objectives (Georghiou, 1998). It is the particular blend of these that, together with institutional legacies and idiosyncratic political and administrative features, determines and characterizes the individual approach and actions of national governments, research agencies, universities, or companies (Kuhlmann, 2008).

At the grounds of everyday routines and operations SD is an arena populated by a myriad actors and concerns. The further we get into IR, global challenges, security issues or competence development in poor regions of the world which a number of countries rank high in their SD agenda, the fewer similarities and the less isomorphism we find in their approaches and policies.

For heuristic purposes, we draw upon *three goals* to characterize different varieties of policies and strategies to promote international scientific cooperation and to do SD.

Access

Access to researchers, research findings and research facilities, natural resources and capital: here, the thrust is to improve national innovation capacity and competitiveness:

- By way of benchmarking international R&D trends and policies;
- By spotting new technologies, scientific discoveries and research potentials;
- By seizing new markets, knowledge and key technologies; and
- By attracting foreign talents and investments.

Access-driven initiatives also carry opportunities for value-driven or merely instrumental activities to ease tensions between states, build trust, and manage or prevent conflicts which may or may not be made explicit goals. Furthermore, access is crucial for extremely expensive 'big science' projects that no country can afford to run alone, such as the International Thermonuclear Experimental Reactor or the International Space Station. Often times, even if not always, collaborative projects and programs of such a size are pitched under multilateral international S&T umbrella agreements (ISTA).

Promotion

Promotion of a country's achievements in R&D: as part of a nation's global marketing efforts, SD and collaboration in S&T are geared to attract the world's best students, researchers and companies. Getting them interested in its R&D may help raise the country's academic capacities, reputation and performance, stir innovations or enhance its innovative capacities, and lay grounds for sustainable international partnerships of mutual benefits.

Influence

Influence on other countries' public opinion, decision-makers and political or economic leaders (plus leaders to be): 'soft power' has been defined as a nation's ability to attract sympathy, talents, capital, and political support to improve both its leverage and international standing (Nye, 1990). Under such a heading, S&T activities appear to be:

> a promising entry point for engaging citizens and civil society organizations worldwide. (Lord and Turekian, 2007: 769)

The global spread and assertion of norms and values associated with scientific research such as rational reasoning and deliberation, universalism and disinterestedness, the acknowledgment of better data or arguments regardless of who is putting them forward, so it looks, will bolster peaceful development and conflict resolution even in non-democratic, authoritarian societies.

For foreign ministries, SD is but a specific aspect of international S&T policy that co-evolves alongside numerous topic-driven S&T initiatives and cooperation arrangements under the purview of other departments, intermediary organizations, universities or semi-autonomous R&D agencies, most of whom want to follow through with their own agenda. The challenge to SD in a more narrow sense as well as international S&T collaboration more generally thus lies in the ability to team up different players, to effectively buy into their capacities in a way that joint priorities and objectives become feasible, and above all to devise customized approaches for different target regions, issues of particular strategic interests, and global concerns. With respect to characterizing different national policies, this means that organizational arrangements, in particular the division of labor and program responsibilities among government departments, research institutions and the private sector, and governance modes, in particular funding streams, decision-making and coordination, become another distinctive feature second to goals and objectives.

The scope and resources for the programs managed by the diplomatic missions in comparison to those of other domestic stakeholders make a big difference, as does the extent to which researchers and research institutions become an integral part of these programs rather than just agents

Toward a typology of national approaches

While a growing number of states has come to appreciate the opportunities, but also threats, of an accelerating internationalization of S&T for their economic prospects and thus begun to engage S&T in their IR and foreign policy, their individual approaches to collaborative projects differ widely from one another, and so does their foreign ministries' SD. Primarily, of course, these variations result from diverging emphases and goals, but to a large extent they also reflect different domestic policy-sets and governance modes for R&D and innovation. In the light of the still fuzzy and highly contested nature of this emerging crossroad area of IR and science policy, our attempts to gather sound data on the programs and activities of the six countries of our sample, be it with regard to soft issues such as priorities and internal decision making or be it hard facts like resources and staff deployed, ended up in a quagmire.

Except for Switzerland, none of the six was able to provide us with this information, or at least none was willing to frankly share it with us. Hence the following accounts come with a big caveat: they are makeshifts as valid as they could get. Since the data we were able to gather are neither complete nor consistent, it would have been purely speculative to put forward a two-dimensional proxy for national SD differentiating between goals and governance modes. As for the latter, the most we can say is that the scope and resources for the programs managed by the diplomatic missions in comparison to those of other domestic stakeholders make a big difference, and so does the extent to which researchers and research institutions become an integral part of these programs rather than just agents.

France

With branches in 26 countries, France's Foreign Ministry operates the largest SD network there is. Not surprisingly, it has the most staff to run it with resources at their disposal that, at least at first sight, seem to pale those of the five other countries in our sample. In the USA alone, France keeps 36 full-time attachés and senior administrators at six locations. Yet contrary to what one might expect from a system of government as highly centralized as in France, France's international S&T policy is governed like a holding in which different research institutions and government departments tender their programs and initiatives (Mustar and Larédo, 2002) and employ their own staff under the roof of France's missions or cultural centers abroad. Nominally, the Quai d'Orsay is in charge of all programs, sub-organizations, and S&T officers. Yet in reality it merely acts as an interest-broker for stakeholders such as the Ministries for Research or for Sustainable Development, funding agencies, or national research organizations.

Under this kaleidoscopic approach, the Centre National de la Recherche Scientifique, individual universities and *grandes écoles*, the newly established French National Research Agency, independent research institutes for medicine or agriculture, and technical agencies such as those for aviation or nuclear energy pursue their vested interests in selected locations abroad. The best way to describe France's SD thus is a three-dimensional matrix that has different world regions or countries on one axis, agencies and their respective programs on the other two.

Science attachés are seconded from different institutional stakeholders according to their individual agenda with respect to the region. 'Science envoys' therefore juggle two identities: as diplomats and representatives of their employing institution. Most of them identify with their employing institution and its institutional culture rather than with the Foreign Office's code of conduct. Unlike most of their colleagues from the other five countries, they are in charge of a large array of programs that have considerable funds coming with them. Moneywise, their biggest chunk is dedicated to promote 'brain circulation' through stipends for postgraduate studies or research fellowships in France.

Main objectives for France's SD are to get access to S&T resources, to look for, and track, promising new trends in R&D in the targeted countries or regions, and to recruit potential partners for collaborative projects. Marketing high-tech products and France as an attractive location for foreign investments is an inherent part of the business.

Unlike most of its competitors, here France strongly emphasizes, and nourishes, bi- and multilateral ISTA. They are to serve as a platform for all kinds of collaborative activities, long-term partnerships with foreign R&D institutes, and the establishment of research centers under French guidance and funding abroad. On the other hand, with the exception of health issues and agricultural development in sub-Saharan countries, notably its former colonies, France has no apparent explicit agenda to address global challenges employing S&T collaboration or SD.

Switzerland

Switzerland subscribes to an innovation-driven SD that stresses access and opportunity with regard to geographic and subject areas of high strategic importance. Exerting influence in IR or to address global challenges is not on its screen — which does not really come as a surprise for a country of that size with a long-standing tradition of neutrality in international affairs. Yet in the core business of internationalizing its S&T, Switzerland shows a smart, skilful and assumedly highly effective approach that serves its interests well. Once it had identified strategic priorities and primary target regions, the government pitched a framework program to support international R&D activities that included authorized annual funding for a period of four years. For the time being, China, India, Russia and South Africa count as first regional priorities; Brazil, Japan, South Korea and Chile as second. It is for the universities' rectors' conference, the Swiss National Science Foundation (SNF), and the Innovation Promotion Agency to further flesh out the legal framework while individual universities are charged with the handling and management of individual programs.

To date, the country employs 17 science counselors fanned out in 13 embassies across the globe. Most of them are seconded from the Department for Education and Research to that of Foreign Affairs. Next to marketing graduate education and top-notch research in Switzerland, they are to serve as door openers and matchmakers for bilateral partnerships or for program consortia. Once an umbrella agreement that includes a list of consented topics and matching fund provisions has been reached, a university becomes responsible for managing the operations as 'leading house' while the responsibility for quality assurance and evaluation remains with the SNF. This well-elaborated setting allows for a sophisticated combination of bottom-up projects with strategic efforts top-down, ensuring that collaborative programs brokered and facilitated by the government do meet the needs and demands of both the S&T and business communities.

Switzerland's Knowledge Network (SWISSNEX) is another outstanding feature for the promotion of international S&T and SD. To date, the network, under the interdepartmental responsibility of Foreign Affairs and Education and Research, operates five SWISSNEX houses that are not necessarily located in the respective capitals, but in cities with outstanding, vibrant S&T activities (Boston, San Francisco, Bangalore, Singapore, Shanghai, while the premises in Moscow has not opened yet). Equipped with tight public money, a small number of project managers and a director who holds diplomatic status, each SWISSNEX outpost has to prove successful on the local market and to attract private sponsors for partnerships and special programs it is supposed to cater for in the respective host country, and to stage highly visible events for the marketing of Swiss research, products, and culture. Bringing together different interest strands, public and private funding, academic and corporate communities, SWISSNEX has proved an unconventional, hybrid organizational format for the promotion of Swiss S&T that tries to serve both academic and corporate agents to access hot fields and markets in key regions and to max out 'Swiss' as a brand name in the global world of S&T and higher education.

The United Kingdom

In the UK, SD met an unparalleled surge of political interest and administrative backing after 2000. Overtaking access and promotion goals, S&T were all of a sudden primarily taken to be tools to yield influence in IR. While the UK had been one of the first countries to dispatch science attachés abroad (1946 to Washington DC), for a long time this service remained focused on the Western hemisphere and on Japan, with the intention to promote and boost domestic R&D, but also to cultivate 'civil relationships' between the UK and the respective host countries. Until 2000, international S&T collaboration and promotion was regarded as a special, and rather narrow, policy field under the auspices of the Department of Trade and Industry. Then, however, Foreign Secretary Jack Straw jumped on the bandwagon of Prime Minister Tony Blair's millennium agenda for global change, demanding that it should also guide the UK's international S&T policy.

Consequently, the UK's emphasis broadened from hard-core interests in access and promotion only toward strategies to gain influence on other nations to compel them to tackle problems of global reach: climate change and global warming, poverty prevention and sustainable development, infectious diseases and counter-terrorism, to name but a few, called for urgent action and international collaboration, and the

UK Government wanted to show it was ready to take the helm. In the following years, it vastly expanded and strengthened its network of science counselors with special regard to crucial regions and millennium agenda concerns. To guide and fine-tune their activities, it commissioned a whole range of foresight studies (ADL, 2005; Technopolis, 2005). Moreover, it created a new organization under the name of Science and Innovation Network (SIN), that should not only effectively merge influence with access and promotion strategies but also become a new brand of UK SD. Raising attention for global warming clearly comes within influence, but should also be used as much as possible to globally market UK environmental technology and renewable energy devices.

A Global Science and Innovation Forum, created in 2006 and headed by the chief scientific advisor of the then Department for Innovation, Universities and Skills, was meant to identify inter-departmental priorities and become a switchboard for a well-orchestrated science and innovation policy of global outreach. S&T-related interests from all government departments, public agencies (such as the seven Research Councils UK and the Technology Strategy Board), and stakeholders from the private sector should be tied together while each SIN hub should set up its own business plan reflecting its main field of activities under the auspices of the previously consented agenda. At the same time, 'SINners' should scan their host countries for new developments in R&D or business opportunities and pass the findings on to London, that is act as scouts and match-makers for institutions from the UK. In the wake of that realignment, the UK's international S&T policy came to rely on lean management, consultancies, strategic foresight, and programs targeted to 'hot' regions and topics, with stupendous marketing activities as a backburner.

In its heyday, SIN employed some 100 'science officers', most of them career diplomats with science degrees, plus 70 local program officers in 24 countries and 39 locations all over the globe. Due to numerous cabinet reshuffles and policy shifts, the scope and activities of SIN changed considerably after 2007. To date, the network is under the direction of the Department of Business, Innovation and Skills. It calls 'science diplomacy' its first priority, closely followed by 'scientific collaboration in countries of key scientific interest'. UK researchers, however, have come to feel increasingly uneasy about the whole direction of SIN and especially the support it would be able, or willing, to provide to the scientific community. The general verdict against SIN is that it took great pains over gaining political influence but did not really care and cater for the researchers' interests and matters.

As an immediate reaction to these complaints, the Research Councils UK (RCUK) pitched their own internationalization strategy and set up four liaison offices in Brussels, Washington, Beijing and Delhi that work independently from the local SIN hubs. Either integrated into the embassies or separate from them, the branches should serve the UK's R&D community by vetting research opportunities and initiating collaborative projects not for reasons of political convenience regardless of their feasibility or scientific value but because they show strong scientific prospects that are worth being seized.

Germany

Germany's international S&T policies are currently under review. Shortly after the federal government had signed off on its ambitious *Internationalisierungsstragie* in 2008, the Foreign Ministry spearheaded the new cross-departmental approach when, early in 2009, as mentioned above, it launched an *Initiative Außenwissenschaftspolitik*, which called for a better appreciation of Germany's SD, but above all for the provision of additional resources and new strategic features. With interdepartmental talks and quarrels still pending, the Foreign Ministry seems to advocate an influence-based SD, that is, to engage S&T to work on problems of global reach, to build up capacities in developing regions, and to use collaborative research to spread civic virtues and dialogue.

The Ministry of Education and Research (BMBF), on the other hand, stresses access and promotion as key objectives of Germany`s global science policy. Moreover, since it is responsible for nearly all funds and resources spent on cooperative R&D programs and SD, the BMBF has a strong leverage for its claims to have administrative leadership in that policy area. Right now, it looks as if this clash of views between the Foreign Ministry and the BMBF, which is also a clash of different institutional cultures, plus the many diverging interests of other key stakeholders such as the big research organizations will impede, and maybe even thwart, the federal government's ambitions to base its new SD on a broad interdepartmental consensus about strategic priorities. Considering the persisting coordination challenges which the institutional set-up of Germany's S&T system raises (Edler and Kuhlmann, 2008), such a reboot is very unlikely to happen soon, if at all.

Bilateral umbrella-agreements (ISTA) serve as basic building blocks for Germany's international S&T activities. Focused on access and promotion, they cover 14 areas of special importance for technology development plus a few projects linked to economic cooperation and development in the southern hemisphere. Eighteen science counselors at German embassies, most of them seconded experts from the BMBF, are to initiate, monitor and back the programs from an administrative perspective, mostly at the government level, but not to act as program managers. Though the Foreign Ministry shares responsibility for SD with the BMBF, the BMBF clearly has the last say and programmatic expertise. The few career diplomats in charge of SD are mostly stopgaps, and it is only recently that their ministry has taken a more active stance in that policy field.

Apart from different departments of the Federal Government, national research organizations, first and foremost the DFG and the Max-Planck Society, but also some non-university research centers belonging to the Helmholtz Association or the Fraunhofer Society for applied and contractual research have turned from being passive stakeholders in international S&T policies into becoming active players with vested interests. Like the UK's RCUK, they have opened offices or branches abroad and try to feed into collaborative ventures on their own account. As far as access and promotion are concerned, thanks to a remarkable growth in federal and state appropriations during the last decade, the German Academic Exchange Service could considerably broaden and upscale its mobility programs and other global marketing efforts for German higher education. Correspondingly, the Alexander von Humboldt Foundation (AvH) extended its much sought-after visiting programs for young researchers and senior scholars from abroad. It encourages more than 25,000 academics it has sponsored to become members of the AvH's global network and to serve as German 'science envoys', trust-brokers and bridge-builders to both civil society and academia especially in the BRIC states and other rapidly developing countries in Asia and Latin America.

Although the *Initiative Außenwissenschaftspolitik* called for more strategic focus, additional funding, new programs and tools in global S&T collaboration, it fell short of assigning SD a stronger role in Germany's IR. The emphasis remains on fostering innovation, improving global competitiveness, and promoting German higher education and science abroad, especially in those countries and regions that show strong developmental dynamics and economic growth. Under this heading, mimicking the SWISSNEX example, the Foreign Ministry recently decided to fund jump-start German Science and Innovation Houses in Moscow, Delhi, Sao Paulo, and Tokyo, that will host offices of the most important German research and business organizations and serve as a one-stop agency for the promotion of German R&D.

Meanwhile, it looks as if SD could gain a hitherto unexpected momentum. Word has it that four federal ministries (for Economic Cooperation and Development, for Education and Research, for the Environment, Nature Conservation and Nuclear Safety, plus the Foreign Office) intend to commission the AvH to set up programs directed to problems of cross-border or global reach, such as climate change or infectious diseases. Until now, AvH prides itself on picking fellows on the basis of merits and bottom-up through academic peers only but to refrain from any directed-mode, targeted funding. The new program would mark a paradigm shift in Germany's SD: under the new policy, the foundation will become an agency of public diplomacy which up to now has not been on the German Government's screen.

Japan

For quite some time already, Japan's Foreign Ministry had taken provisions to address S&T cutting across security issues. Yet it had little or no capacity to deal with pressing global challenges such as the environment, renewable energy or the potential and risks inherent in the rapid development of modern life sciences (Yakushiji, 2009). Currently, Japan's SD presents itself as a blend of conventional foreign policy concerns, such as containing or counterbalancing China's rising influence in sub-Saharan Africa or the non-proliferation of nuclear weapons, and an ambitious innovation agenda to help enhance the nation's performance in S&T. With regard to Japanese S&T, the government's third S&T Basic Plan 2006–2010 zoomed in on life sciences, material sciences, IT, space and marine technologies as strategic priorities.

Compared to Japan's main competitors, its basic research performance is far from excellent but rather shows some telling weaknesses and shortcomings. That is why the high-ranking Council for Science and Technology Policy (CSTP), fearing this lag might spoil Japan's capacity for innovation and competitiveness, commended an internationalization agenda for R&D with access and promotion as key objectives. Under this heading, the Ministry of Foreign Affairs (MOFA) set out for a substantial expansion and enhancement of SD services in diplomatic missions abroad. It decided to dispatch 27 new S&T officers to embassies that up to now have no science attachés seconded from the Ministry of Education and Research (MEXT).

Among the most important issues to be tackled are establishing, or getting access to, advanced research facilities outside of Japan, and improving the global marketing of Japanese S&T through mobility grants, collaborative programs and the appointment of excellent Japanese researchers as 'science and technology ambassadors'. The policy also involves the sales promotion of new cutting-edge technologies made in Japan under the auspices of advocating, and campaigning, for global change and environmental protection.

For daily uses, Japan's SD, like that of France, draws heavily upon more than 40 ISTA both with highly industrialized and developing countries, and Strategic International Cooperative Programs which the Japan Science and Technology Agency (JST) operates under guidelines of, and with funding from, the MEXT. Some programs are run in a triangular partnership with China and South Korea.

The institutional design for Japan's SD holds some surprises. From a country which appears to, and is commonly also understood as being centrally governed and tied in corporatist arrangements, one would expect the organization of its SD, above all in its outposts abroad, to be completely streamlined. In striking parallel to France, however, many of Japan's non-university R&D organizations, such as the Japanese Society for the Promotion of Science (JSPS), the aerospace exploration agency JAXA, the Marine-Earth S&T Agency or JST not only dispatch their staff as S&T counselors to embassies, but in many places also run their own offices next to these. While the MOFA to date employs only two science counselors (in Washington DC and Brussels) and seven science secretaries in its embassies worldwide, each of the other agencies runs three or four (JSPS even ten) international branches, all of which have more than just one full-time program officer. Most of them are devoted to access and promotion goals for Japanese R&D, high-tech products and services, whereas MOFA pushes for paying influence more regard.

Due to this compartmentalized setting that includes and fosters strong competition among the different organizations (government departments and agencies), a coherent strategy for SD is extremely difficult to get at. Contrary to our preconception and to the standard public self-presentation of Japan's S&T policies, in reality these are far from well-organized, top-down but rather mirror an incremental approach that tries to feed strong inter-institutional competition into some kind of strategic cooperation. While science counselors and secretaries working under the direction of MOFA unanimously told us Japan's SD would suffer from poor coordination, the officers representing S&T agencies and organizations, on the other hand, were keen, and proud to be able to pursue the kind of SD they thought would fit their interests best. While it is an open question whether the seeming lack of coordination derives from characteristic weaknesses in the organizational set-up of the CSTP (Tanaka and Hirasawa, 1996), it is next to impossible to tell what better coordination could mean, where it might lead Japan's SD to, and whether, considering the circumstances, this would really be the way to go.

The United States

In the USA, a plethora of government departments, basic research and mission agencies, and (semi-) private organizations engages in S&T, each of them responsible for different aspects of a policy agenda which they themselves help to shape and have stakes in. While overall policy coordination for S&T activities is assigned to the White House Office for S&T Policy, there is no equivalent to a science ministry. This approach works well for achieving specific agency goals, yet does not provide the best set-up to effectively pursue foreign policy objectives with major S&T components since each and every agency is bound to follow just its own goals and priorities. In such an institutional setting, international S&T policy cannot become anything but highly fragmented, imponderable and inward-looking.

Since it has no funds to foster international scientific collaboration, the Department of State (DoS) has just a very narrow role and little say in global science policy. Ironically, this impedes its capacities to do SD at a time when US foreign policy is beginning to appreciate the possibilities of public diplomacy and to buy into 'soft power' to influence public opinion in other countries to nudge for compliance with its political goals. As a weary political scientist put it in 1998:

> among the world's leading nations, its process for developing foreign policy is the least well coordinated with advances in S&T and the policies affecting them. (Ratchford, 1998: 1650)

While the DoS is in charge of negotiating and monitoring umbrella ISTA, of which there are now 36 active in place, it has neither the administrative responsibilities nor the human resources necessary to design, let alone to carry out collaborative programs or other research-related activities. All these rather fall under the purview of specialized agencies. Unlike in most other cases, ISTA with the USA do not bear a commitment of the signatories to spend money together. This is one of the reasons why they are not taken very seriously. The coordination and representation for all international R&D issues nominally falls to the State Department.

As the nature and importance of these issues have considerably changed over the years, so did the departments' organizational structure. For a short period of time in the 1950s, the DoS had its own science advisor. This position reflected the important role nuclear and other weapons technology had for national security during the Cold War. In 1974, science in IR had changed to more of a civilian focus and Congress created the position of an Assistant Secretary of State for Oceans, International and Environmental Affairs (OES) within the DoS as a presidential appointment requiring Senate confirmation. The creation of a unit dedicated to such topics underlines the USA has come to acknowledge the rapidly growing importance of global science and environment issues.

The DoS began losing its interest and ability to deal with those issues, however, when, in the 1980s, and accelerating into the 1990s, decreasing foreign operations budgets led to large-scale cuts particularly for the science capacity. In an attempt to alleviate the problem, Secretary of State Madeleine Albright requested that the US National Academy of Sciences provide their guidance on how the State Department could better attend to areas involving S&T affairs and to the intersection of science and foreign policy. The resulting report stressed the role of science for major US foreign policy objectives and recommended increasing science capacity within the ministry, including the creation of a science advisor position (Pickering and Shine, 2001). Programs such as the AAAS diplomacy fellowships and the Jefferson Science Fellowships bring nearly 50 young scientists into the DoS each year to serve as short-term advisers and foreign-policy practitioners. To date, its OES Bureau employs some 200 staff and serves as a home base for an unreported number of career diplomats who work as science counselors or secretaries at the Environment, Science, Technology and Health (ESTH) units in US diplomatic missions.

The lack of expertise and presence in these domains represents a blind spot of the DoS in international science policy that has already earned severe criticism both from within the administration as well as from the academy and especially the IR community. In the daily work of the ESTH offices, backstage services to facilitate projects for research institutions, companies or individual scientists, non-proliferation and biodiversity issues, counter-terrorism and quarrels over IPR take up most room whereas institutional scientific collaborations are not much sought-after and marketing US R&D or higher education are not considered part of the science counselor’s job.

Recently, the US Congress has attended to international S&T. On 26 March 2009, a bill was introduced to the House:

> to provide for the establishment of a committee to identify and coordinate international science and technology cooperation that can strengthen the domestic science and technology enterprise and support United States foreign policy goals.[12]

Soon after the International Science and Technology Cooperation Act that had called for dispatching US ‘science envoys’ all over the world and for establishing a ‘global science fund’ to support international collaboration in S&T failed to pass, Congressman Berman, chairman of the House Foreign Affairs Committee, introduced bipartisan legislation to enhance US efforts at science diplomacy. While still pending, this development clearly demonstrates a rising political awareness of these issues.

Implications and conclusions

The overall picture that emerges from comparing these six major players’ approaches to dealing with the many challenges and opportunities an ever-increasing internationalization of S&T poses to both their national innovation strategies and foreign policies is as enticing as it is ambivalent. On the one hand, somehow or other all countries have taken an active stand and initiated new policies, tools and practices, and mobilized extra resources to better serve these issues. On the other hand, their individual perspectives, approaches, and practices differ widely from one another. In stark contrast to more conventional policy fields, there is no such thing as an acknowledged state of the art of how to do SD or a consensus on what SD could or should be — at least not as yet.

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While some of the reasons for that disappointing picture — the disparity of organizational actors, stakes and problems, multiplied by many overlaps with other policy fields — are fairly obvious, others, such as a strong tension between cooperation and competition which characterizes that arena both in national and in international perspective, are not. Increasing internationalization of R&D entails growing competition between nations and their administrations that are on the look-out for competitive advantages and itchy to take the helm in key technologies. The EU, for instance, has tried to accommodate tensions between member states tendering for research funds from its initial Framework Programs by stressing these would cover only ‘pre-competitive research’. Moreover, SD is a domain which has to address and cope with two seemingly antagonistic modes of orientation and social interaction, one being the informal regime of academic peers, judgment, and merits, and the other formal organizations, authorities, and hierarchies (Stein, 2002a).

All nations of our sample, plus the EU, share the view that newly industrializing states are destined to be engines of worldwide economic growth and innovations. Hence they feel they should try to tap into and get a hold of these assets — the sooner the better. They also share concerns about the rising risks and dangers of climate change, a spread of infectious diseases, increasing energy costs, migration movements, and cultural clashes, to name just a few. Governments are well aware that S&T cut across national politics and feel confident they can be engaged to tackle and hopefully solve these global problems. However, the degree to which their international S&T policy is guided by one or the other strand of reasoning, by offensive or defensive objectives or by a blend of all these varies considerably. While for the USA and the UK political influence plays an important role for their SD, Germany, France, Switzerland, and Japan mainly focus on getting access to promising markets and developments in R&D and on promoting their S&T, research and higher education on the global marketplace, with trailblazing high-tech products in the first place.

The great variety of approaches, both in goals and means, suggests it is futile to look for a one-size-fits-all model to deal with international S&T and SD. Instead, different institutional settings and political trajectories, interests and governance modes entail different approaches that are still difficult to clearly tell apart. However, it seems possible to draw some lessons on what is needed to effectively put forward the three main goals sketched out earlier — access, promotion and influence — and what will rather not work.

As for influence, the use of S&T as a collaborative venue, 'soft power' and bridge-builder between nations, interests, and communities hostile to one another calls for customized approaches that heavily bear on background knowledge, personal links, experience and skills. There is neither a handbook for how to play science for diplomacy nor a metric to measure what R&D, and cooperative programs, contributed to manage, prevent or solve conflicts (Weiss, 2005). However, one critical success factor for an influence-orientated SD is fairly obvious: It is crucial to get the right people to the job, be they career diplomats who are familiar with S&T or S&T professionals who command excellent personal skills and political judgment.

With respect to access and promotion objectives, things become less murky. Here, it is essential to weigh on, and eventually mobilize, the vested interests of relevant stakeholders (government departments or agencies, scientific and business communities) with the intention of forming alliances on a common ground of shared responsibilities and mutual benefits. Both investment and outcome can be accounted for, and it is fairly easy to tell which incentives work and which do not. The Swiss example demonstrates what a smart institutional arrangement and effective incentives may look like. Again, recruitment is a crucial issue. Depending on the S&T counselors' prime chores, they might be career diplomats who are capable of comprehending and cherishing key issues of this policy field, or coming from S&T and taking political bearings.

Regardless of which goals come first, which strategy looks most promising, and up to which department or agency it is to carry them out, leadership becomes crucial in what has become a global war for talents and opportunities. Many of the obvious shortcomings, ambiguities, and inefficiencies in the ways to do SD can be associated with a lack of leadership, starting at the level of agenda-setting up to the 'machinery of government'. Yet this does not mean that any compelling SD has to start with convening top-ranking committees to elaborate strategic guidelines that then need be pushed down the throats of the executive branch for successful delivery. Rather, the challenge lies in an effective, recurrent and sustainable combination of bottom-up interest aggregation with strategic decision-making. For that, we have found an impressive range of best practices.

The two most important lessons are fairly simple: To be successful in doing SD by any measure, a country has to be very clear about both its overall strategy and who should be in charge to carry it out. Often times, potential partners abroad do not know what is being offered to them and to whom they can turn with questions, project proposals, or grant applications.

Second, *exploiting* science for political purposes — to brag about competence in hot high-tech fields or research areas or to demonstrate goodwill in IR — makes little or no sense. For collaboration to take off and become gratifying for all participating parties, it is vital to engage the curiosity and interests at least of those scientists who are considered to run the collaborative program or venue. 'Systemic' strategies need not only to be compatible with bottom-up project proposals, informal ties and academic interests, but also have to make them fit in.

Last but not least, one needs to caution not only against overstretching S&T for short-term political goals, but also against overrating the potential benefits of S&T for improving IR. Science and collaborative research work are no panacea for easing conflicts or improving stale relations between nations. Nevertheless, they may become important incubators for international cooperation in a post-national world that faces ever new global problems, and for the cultivation of civil relations that are based on mutual respect, shared values and common standards in the global company of science.

Notes

1. The pace and patterns of international collaboration in S&T can be easily measured country by country by the percentage share of all scientific articles that are internationally co-authored over time. The 'Science and Engineering Indicators' the US National Science Board publishes every other year cover all relevant data; the 2010 edition is available at <http://www.nsf.gov/statistics/seind10/>, last accessed 4 April 2010.
2. The latest 'Global Competitiveness Report 2009-2010' of the World Economic Forum ranks Switzerland first and the USA second. See <http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm>, last accessed 4 April 2010.
3. <http://www8.cao.go.jp/cstp/english/policy/stdiplomacy.pdf>, last accessed 2 April 2010.
4. <http://www.auswaertiges-amt.de/diplo/de/Aussenpolitik/KulturDialog/Aussenwissenschaftsinitiative2009/Ziele.html>, last accessed 2 April 2010.
5. <http://www.nsf.gov/nsb/publications/2008/nsb084.pdf>, last accessed 3 April 2010.
6. Quoted from CSD's homepage at <http://diplomacy.aaas.org/about.shtml>, last accessed 3 April 2010.
7. <http://ec.europa.eu/research/press/2008/pdf/com_2008_588_en.pdf>, last accessed 3 April 2010.

8. Our research was funded by a grant from the German Federal Ministry of Education and Research and technically supported by the German Foreign Ministry. The final report – *Aufgabenkritische Analyse deutscher Außenwissenschaftspolitik (AWP) in sechs ausgewählten Zielländern.* Berlin: Wissenschaftszentrum Berlin für Sozialforschung – was released as a working paper in May 2009.
9. To track and weigh the historic intersections of S&T and IR in greater detail would go far beyond the scope of this article. Suffice it to say that the few milestones mentioned here are to illustrate the long-standing mutual pervasiveness of S&T and IR and many different forms it can take.
10. From the ISTC mission statement, <http://www.istc.ru/istc/istc.nsf/va_WebPages/MissionEng>, last accessed 22 June 2009.
11. From the CRDF's 1998–2000 Program Report, p. 2, <http://www.crdf.org/annualreport/1998_2000_program_report.pdf>, last accessed 3 June 2010.
12. <http://thomas.loc.gov/home/gpoxmlc111/h1736_ih.xml>, last accessed 10 April 2009.

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