The Objectives and Governance of Science and Technology Diplomacy: A Preliminary Comparative Analysis

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Abstract

Science and technology diplomacy has become an important policy agenda because of its diplomatic utility and enhancing of international science networks. However, different countries possess different objectives and governance of S&T diplomacy. In this context, this paper seeks to answer the following questions: what are the similarities and differences of S&T diplomacy in countries and what shapes these characteristics? To answer these questions, this paper conducts a comparative case study with five countries – Switzerland, Germany, Japan, the United Kingdom, and the United States – whose S&T diplomatic programs are highly recognized and benchmarked by other countries. A useful typology is devised to conduct a systematic comparison. For S&T diplomatic objectives, this paper suggests five types by elaborating concepts from the previous literature: access diplomacy, promotion diplomacy, public aid diplomacy, functional diplomacy, and global leadership diplomacy. Also, in terms of a governance model for S&T diplomacy, three models – a science-centered model, a science-outsourcing model and a top-down coordinating model – are suggested based on leadership organization. This paper reveals the different characteristics of the selected countries in S&T diplomacy. While the selected countries pursue almost every type of S&T diplomatic objective, the US and the UK tend to conduct influence-based diplomacy more than other countries do. In addition, different countries each have unique governance models for S&T diplomacy. While more research is necessary for vigorously testing the causes of different objectives and their relationship with governance models, this paper suggests more general policy implications throughout. The strength of the country's S&T base is fundamentally important for the success of S&T diplomacy. However, domestic S&T assets need to be transferred to its diplomatic capabilities. In this sense, the appropriate governance that fits best with the country's S&T mission should be established, while S&T communities should increasingly play a leadership role in evolving global S&T networks.

Keywords
S&T diplomacy, objectives, governance models, S&T communities

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1. INTRODUCTION

1.1. Research Background

The innovative characteristics of modern science in contemporary global economic systems instigated the expansion of scientific networks beyond national borders. The monopoly of a specific technology has become increasingly incompatible with innovative market systems as new ideas and products likely result from the convergence or fusion of different sets of scientific knowledge (Lee & Yoon, 2012). In addition, international scientific cooperation may reduce financial and innovation risks.[1] Therefore, there is strong incentive for national scientific and industrial communities to cooperate with foreign scientists and form an "invisible college".[2]

On the other hand, the increasing importance of public diplomacy in the 21st century has revived science and technology (S&T) diplomacy as a field of interest.[3] Policymakers began to look for ways to "win the hearts and minds" (Nye, 2004) of foreign publics in achieving a country's political interest, and S&T diplomacy has provided a useful tool for that purpose. Although the idea of using scientific knowledge for diplomatic purposes is not new,[4] the growing importance of public diplomacy in the globalized era – where diplomacy is conducted not only by official diplomats but also by civil groups such as students, professionals and business communities across multiple social dimensions – highlights the role of science in international affairs.[5]

1.2. Research Purpose and Design

Diplomatic usefulness and deepening international networks in science and the economy has made S&T diplomacy an important part of the national policy agenda. However, science and diplomacy are fundamentally different fields with distinct purposes and functions. Countries take different approaches to the governance of S&T diplomacy and its implementation methods. In this context, this paper seeks to answer the following question: what are the similarities and differences in the S&T diplomacy policies of different countries, and what are the reasons for these differences? The purpose of this paper is to empirically present the overall portrait of individual countries' S&T dip-

[1] Large-scale equipment-based programs such as the International Thermonuclear Experimental Reactor (ITER), the International Linear Collider (ILC), the BeppoSAX, and the Human Genome Project are good examples for international cooperation supported by S&T major countries.

[2] The term "invisible college" was first coined by Robert Boyle in 1645 to describe links among researchers that extend beyond particular institutions and places. This term was adopted again by Wagner (2008) to illustrate self-organizing networks by researchers that span the globe in the 21st century.

[3] The term "public diplomacy" was first used by Edmund Gullion in 1965. For the role of S&T in public diplomacy, see Lord and Turekian (2007).

[4] Diplomatic missions using science and technology were already discussed after World War II. Lloyd V. Berkner's report on "Science and Foreign Relations" for the US Department of State (DOS) is a notable example.

[5] For example, in February 2014, three US scientists visited Iran and explained the purpose of their visit: "The purpose of our visit was science diplomacy: to meet people on their turf, and to initiate and encourage scientific connections while getting at least a cursory first-hand look at the academic and scientific atmosphere in Iran" (Pickett, Leggett, & Chu, 2014, p. 465).

lomatic activities and to identify relevant structural or behavioral factors that affect these characteristics. By doing this, the paper constructs a useful typology to better understand S&T diplomacy and to reveal important elements that shape countries' international scientific activities.

To fulfill this goal, this paper adopts a comparative research method with five country cases.[6] Both primary and secondary sources are used to describe a country's different objectives, leadership departments, and its encountered issues. Most previous literature on S&T diplomacy is conceptual or anecdotally based on a few events. The contribution of this paper is to sort through the previous material and systematically categorize countries based on their S&T diplomatic characteristics. This task contributes to building a testable theory in the future, while policy implications are generated by comparing different cases.

The selection of cases is somewhat subjective. Because there is no firmly established theory of S&T diplomacy, the selection process is not based on a logic for testing specific hypotheses. Instead, the paper selects five countries – Switzerland, Germany, Japan, the United Kingdom, and the United States – whose S&T diplomacy has been often benchmarked by other countries. The primary period of analysis is in the 2000s when the interest of S&T diplomacy reemerged across countries.

The following section deals with the objectives and governing models for S&T diplomacy; this paper first clarifies important concepts and suggests its own typology. In terms of the objectives of S&T diplomacy, this paper, based on the Royal Society (2010) and of Flink and Schreiterer (2010), suggests five categories: to access (access diplomacy), to promote (promotion diplomacy), and to influence other countries (public aid diplomacy, functional diplomacy, and global leadership diplomacy). For governance models of S&T diplomacy, this paper suggests three models:1) a science-centered model, 2) a science-outsourcing model, and 3) a top-down coordinating model.

The S&T diplomacy policies of five countries are then introduced with their major programs and characteristics. The focus of this narrative section is to provide an overall view of S&T diplomatic program in individual countries. The next section conducts analyses on these cases according to their objectives and governance for S&T diplomacy. Supplementary materials, such as the Organization for Economic Cooperation and Development (OECD)'s *Science, Technology and R&D Statistics,* are utilized to support the analysis. The conclusion section suggests future research for going beyond the limits of this study and provides general policy implications for S&T diplomacy.

[6] Because quantified data on a country's S&T diplomatic activity, such as budgets, personnel and locations, have not been accumulated enough or been publicized by individual countries, a large-N analysis is not feasible.

2. S&T DIPLOMACY: OBJECTIVES AND LEADERSHIP ORGANIZATIONS

2.1. The Objectives of S&T Diplomacy

"Science and engineering activities have always been international" (Stine, 2009, summary page). As a part of international science, S&T diplomacy is simply using S&T as a diplomatic tool. What most distinguishes it from other patterns of knowledge flow is that governments are directly or indirectly involved in international scientific and engineering activities for national interests. On the other hand, diplomacy also plays an instrumental role in S&T diplomacy; in other words, science itself becomes the goal for a diplomatic mission. Scientific communities use diplomatic channels for their own interests.

The Royal Society (2010) illustrates this relationship between science and diplomacy by defining the concept of S&T diplomacy in three dimensions: diplomacy for science, science for diplomacy, and science in diplomacy. Diplomacy for science means "facilitating international science cooperation" while science for diplomacy indicates "using science cooperation to improve international relations between countries." Science in diplomacy, on the other hand, is "informing foreign policy objectives with scientific advice" (The Royal Society, 2010, p. vi). Therefore, according to the Royal Society's definition, the three features of S&T diplomacy are : 1) science can be used for a diplomatic goal; 2) scientists or a scientific group has the potential to become an equal player with the government in order to conduct S&T diplomacy, that they have their own objectives and can utilize a country's diplomatic channels for themselves; and lastly, 3) in modern diplomatic activities, scientific knowledge and technologies became integral and indispensable for achieving policy goals.[7]

The Royal Society's language can be translated into more functional types of S&T diplomatic objectives. Flink and Schreiterer (2010) suggest three objectives of science diplomacy: access, promotion, and influence. Although these three objectives are not completely mutually exclusive from one another, they are distinguishable as overall policy goals: S&T goals (access and promote) and political goals (influence). The first two objectives can be understood as diplomacy for science

[7] It is arguable as to whether "science in diplomacy" from the Royal Society (2010) should be part of S&T diplomacy. The increasing role for scientists in every domain of modern society, including foreign policies, is undeniable. In particular, scientific knowledge is indispensable in environmental or any scientific rule-making negotiation. However, S&T diplomacy in this paper should be distinguished from merely strengthening S&T capacity in the government. The author argues that "science in diplomacy" is rather the basis of S&T diplomacy, not per se; on the other hand, Jang, Bae, Kim, Song, Lee, Lee, Choi, Kim, Lee, and Jang (2012) provides a unique framework on S&T diplomacy by integrating the Royal Society's model with Nye (2008)'s smart power concept. By doing this, they created one more category to the Royal Society's typology science as diplomacy. Science as diplomacy represents the soft power a country projects through S&T development. This concept has great merit as well as limits as a foreign policy tool. The possession of advanced science and technology itself becomes a (soft) power and enhances a country's diplomatic appeal, thus enabling it to simultaneously achieve the purposes of access, promotion, and influence, which are the objectives of S&T diplomacy. However, focusing only on the development of S&T may not be useful in achieving a diplomatic goal because it depends on the other's appreciation. At the same time, to develop a country's S&T capability for science as diplomacy, it may need to conduct access or promotion diplomacy in prior; therefore, this concept is not completely independent from other S&T diplomatic activities. Nevertheless, as this paper emphasizes in the conclusion, the concept of science as diplomacy needs to be integrated into the policymakers' thinking to conduct effective S&T diplomacy centered on the S&T community.

in the Royal Society's terms while the third is science for diplomacy. Governments strive for "access to researchers, research findings and research facilities, natural resources and capital" in other countries through S&T diplomacy. Along with this, countries pursue the "promotion of a country's achievements in R&D" by attracting the world's best students, researchers, and companies. This paper designates S&T diplomacy with the goal of access as "access diplomacy" while calling promotion-based efforts "promotion diplomacy." Both access and promotion diplomacy are aimed at enhancing a country's S&T capability and increasing commercial gains based on the mutual interests of participants.

On the other hand, countries try to obtain "influence on other countries' public opinion, decision-makers and political or economic leaders" by using S&T diplomacy (Flink & Schreiterer, 2010). In this paper, the dimension of influence can be further divided into three sub-categories: influence through international scientific aid (public aid diplomacy), influence through the spread of scientific cooperation into political cooperation (functional diplomacy), and influence through cooperative research projects on global issues, such as climate change, food, energy security, infectious disease, and genetically modified plants and animals (global leadership diplomacy).

Scientific aid is primarily conducted for a humanitarian purpose by advanced countries to strengthen S&T capacity in developing countries. On the other hand, cooperative research on global challenges is not restricted to the developed-developing countries' relations but also includes cooperation among advanced economies. This leadership diplomacy usually requires adequate diplomatic capabilities and scientific resources to effectively tackle challenging global issues and shape global public opinion. Functional diplomacy is conducted based on the postulation that scientists are rational and better equipped to understand their counterparts through common scientific languages that transcend individual nationality. In theory, the concerted cooperation of the scientific community in conflicting countries may decrease the level of tension between them and induce political cooperation with increasing trust. In other words, "individual scientists are valuable ambassadors of goodwill" (Lord & Turekian, 2007, p. 769). This type of S&T diplomacy is only conducted in a particular context. Table 1 shows the summary of this conceptual work.[8]

TABLE 1. Objectives of S&T Diplomacy

Objectives		Characteristics
Access	Access diplomacy	Participating in foreign research projects
Promote	Promotion diplomacy	Inviting foreign S&T organizations and personnel
Influence	Public aid diplomacy	Strengthening S&T capability in developing countries
	Functional diplomacy	Leveraging scientific cooperation for political cooperation
	Global leadership diplomacy	Conducting cooperative research on global issues

[8] Countries also conduct security-related S&T diplomacy bilaterally or multilaterally, e.g. the nuclear non-proliferation regime. This diplomatic type is unique and requires a different approach. Most countries strive to access military technologies of both adversaries and allies and rarely promote their own technologies. The meaning of influence is also different in this type as countries do not encourage but restrict others to possess certain types of S&T knowledge, sometimes with coercive and forceful measures. This paper does not include this specific diplomatic type in the general discussion.

2.2. Governance and Leadership Organizations

Like the objectives of S&T diplomacy, the governance of S&T diplomacy is potentially an important factor that affects the type and content of a country's external S&T engagements. In this particular context, governance is simply "the exercise of authority within a given sphere" that "involves building consensus, or obtaining the consent or acquiescence necessary to carry out a program, in an arena where many different interests are in play" (Hewitt de Alcántara, 1998, p. 105). In this sense, the governance of S&T diplomacy produces external S&T policies and implements them to meet the social demand of international S&T activities.

Major actors in the S&T diplomacy governance are the following: governmental organizations, political leaders, diplomatic circles, and S&T communities – including individual researchers, institutes, universities and business groups – and their international counterparts. It is noteworthy that S&T diplomacy involves a wide range of stakeholders, ranging from different governmental departments to non-governmental organizations. The boundaries between S&T diplomacy and other government-supported international activities, therefore, are potentially very fluid (Berg, 2010). However, the department of foreign affairs and the department of science are indispensable in initiating, implementing, and monitoring S&T diplomacy in cooperation with domestic S&T communities.

Science and diplomacy possess fundamentally different functions; the former generates basic and valuable knowledge for a society and strengthens a country's developmental capacity; the latter pursues the logic of survival and national interest in international relations. For foreign policy advocates, science policy should be used for wider goals, while for scientists to collaborate beyond national interests with the best people in the world and to access the best research facilities. However, in order to conduct S&T diplomacy, science needs diplomacy, and diplomacy needs science. This paper, based on a form of leadership organization, suggests three governance models that bring different arrangements of major players into S&T diplomacy. The leadership is simply determined according to capacity for initiatives, competency to implement, and degree of involvement in S&T diplomacy.

The first model is a science-centered model. In this model, the department of science or other science-related organizations play a leadership role in conducting S&T diplomacy. Because the department of science is relatively competent in dealing with scientific issues vis-à-vis other governmental organizations, this model is considered efficient for pursuing S&T objectives in access and promotion. Although this model tends to emphasize research efficiency and commercial interests over political strategy, it is not purely bottom-up. From the viewpoint of scientists, science departments may still take a government-planned, top-down approach against their will.

The second model is called a science-outsourcing model. Within this model, the leadership role is given to the department of foreign affairs. A country's diplomatic channels are indispensable for conducting S&T diplomacy; the well-established international networks in the department of foreign affairs are essential routes for connecting domestic scientific communities with their foreign

counterparts. In particular, the diplomatic maneuver is required if a country wants to exert influence upon other countries and conduct functional diplomacy. However, the foreign ministry's S&T capacity is severely limited and weak. Even for security issues such as non-nuclear proliferation and weapons of massive destruction, the ministry needs the expert advice and organizational support available from science-related organizations. Therefore, in this model, the foreign ministries outsource to S&T communities in order to conduct S&T diplomacy.

The third model is called a top-down coordinating model in which leadership is given to an office under the President or the Prime Minister. This model's strength is in initiating the S&T agenda and assigning a specific task upon different organizations according to the characteristics of given missions. S&T diplomacy may result from domestic political considerations or broad diplomatic blueprints, and for this reason this model may enhance the overall efficiency of achieving a national agenda, and increase flexibility in international S&T activities. Some countries also use this top-down coordinating model to overcome coordination problems within bureaucracies. Since S&T diplomacy inherently involves different stakeholders with varying objectives, the problem of coordination always exists.[9] A top-down coordinating model, however, has a weakness; the maximum power of the highest office may only initiate and coordinate policy directions but not implement and monitor those policies. As the Japanese case shows, there is always room for bureaucratic inertia or divergence from the national interest.

Like the objectives of S&T diplomacy, the governance model of S&T diplomacy is not mutually exclusive, and a pure example of its type may not be found in reality. According to Berg (2010), among fulltime S&T staff who are mostly given a diplomatic title,[10] approximately 40% and 44 % make up the average proportion of recruited and seconded staff from ministries outside the department of foreign affairs. This means that the proportion of career diplomats is only about 16%.[11] This fact seems to support the predominance of the first model. However, as this paper shows later, some tendency towards the second or the third model is indeed observable in particular circumstances. For example, the UK and Germany somewhat, have tried to strengthen the S&T capacity of their foreign ministries since 2000. In addition, despite many limits, the US closely belongs to the second model as shown below. Lastly, the Office under the Prime Minister in Japan initiated S&T diplomacy in 2008, indicating the third model. Table 2 shows the different types of governance models for S&T diplomacy.

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[9] Painter (1981) provides an instrumental definition of policy coordination: 1) avoidance, or at least minimization, of duplication and overlap; 2) avoidance of policy inconsistencies; 3) Minimization of conflict, both bureaucratic and political; 4) quest for coherence and cohesion and an agreed ordering of priorities; and 5) promotion of a comprehensive or 'whole government' perspective against the constant advocacy of narrow, particularistic or sectoral perspectives.

[10] The terminology used for scientific specialists assigned to the embassies varies: science counselors; science and technology counselors; environmental, science, and technology counselors; science attachés; science officers; and environmental officers, for example.

[11] When partial S&T staffs are included, the ratio of career S&T diplomats slightly increases to 25% (Berg, 2010), Berg's survey-based research for twenty countries is one of a few studies conducted to show numerical values on international S&T diplomatic activities.

TABLE 2. Governance Model of S&T Diplomacy

Model	Leadership Organization	Characteristics
Science-centered	Department of science, or science-related organizations	Efficient for S&T goals
Science-outsourcing	Department of foreign affairs	Efficient for political goals
Top-down Coordinating	Office of presidency or prime minister	Integrating different goals Flexible for conducting specific missions

3. S&T DIPLOMACY: COUNTRY CASES

3.1. Switzerland

Switzerland pursues S&T diplomacy for its access to foreign scientific technologies in strategically important regions, and seeks opportunities to promote its own S&T programs. As a small but innovative country, Switzerland finds it important to use international networking in S&T for economic growth. As of 2014, eighteen science and technology counselors were dispatched in eighteen embassies, and most of them were seconded from the State Secretariat for Education, Research and Innovation (SERI). Science counselors dispatched from SERI market graduate educational programs and high-tech research projects in Switzerland, and act as matchmakers for bilateral partnership programs. When agreements are signed with counterpart countries, implementation is conducted by universities and the Swiss National Science Foundation (SNF). Universities are given a role in managing programs and the SNF evaluates them. Hence, this system is likely open to bottom-up participation rather than top-down approaches in building S&T capacity. The government acts as a coordinator between the academic and business communities (Flink & Schreiterer, 2010; Schlegel, Jacot, & Fetscherin, 2011).

Switzerland's Knowledge Network (SWISSNEX) acts as an integrated model of science, business, and culture and shows another important feature of Swiss S&T diplomacy. SWISSNEX is operated by SERI in close cooperation with the Federal Department of Foreign Affairs (FDFA), and as of 2014 its outposts were located in strategic cities for S&T activities such as Boston, San Francisco, Bangalore, Singapore, Shanghai, and Rio de Janeiro (SWISSNEX, n.d.). This program is well designed to effectively access outstanding S&T activities in emerging regions. Each SWISSNEX house is supported by S&T counselors dispatched to the relevant host country. One-third of the budget is provided by SERI while the remaining two-thirds are generated through third-party funding. In this process, different stakeholders voluntarily participate in S&T activities. By holding highly visible events that hybridize science, business, and culture and by bringing together different interests of public and private organizations, SWISSNEX is often referred to as a successful case of S&T diplomacy for enhancing Swiss research interests and commercial products (Schlegel et al., 2011). This model has been benchmarked by Germany, the UK, and Ireland while other countries, including South Korea,[12] recognize it as a successful case of S&T diplomacy.

[12] The author's interview with a science envoy from South Korea in Washington D.C. (February 13, 2015)

Switzerland actively utilizes the advantage of its geography in Europe. The European Organization for Nuclear Research (CERN) was established in 1954 in Geneva, and Switzerland is a founding member. The country has also participated in the European Framework Programmes (FP) since 1987 as an associated member in order to access European S&T resources.[13] While Switzerland has significantly benefited from the FP,[14] it also uses its associated member status to leverage its relations with non-European countries by providing them a pathway to access European S&T capacity.[15]

It should not be said that Switzerland has no international S&T program to influence other countries. The Swiss scientific aid program is presumably strong, considering its high commitment to international development assistance as this paper later shows. Also, the Swiss Health Foreign Policy launched in 2006 by the Federal Department of Home Affairs (FDHA), and the FDFA have a mid-term goal of promoting research to strengthen the empirical basis for effective health interventions in developing countries (Gagnon, 2012). However, the portion of this global leadership program is still relatively small compared to other S&T diplomatic activities. Therefore, the primary characteristic of Swiss S&T diplomacy is its access and promotion-based approach while its traditional aid programs support public aid S&T diplomacy.

3.2. Germany

Germany has pursued international cooperation based on the principles of mutual interests and pragmatism. It has actively participated in the FP[16] and CERN. In particular, some of the first post-World War II contracts between German and Israeli scientists were through the CERN projects (Lijesevic, 2010), an example of opportunistic functional diplomacy. Germany has also conducted a large amount of scientific aid programs mostly in African countries through the German Agency for International Cooperation (GIZ).

The Federal Foreign Office and the Federal Ministry of Education and Research (BMBF)'s International Bureau exerts power in S&T diplomacy through its own international outreach programs. As of 2010, eighteen science counselors were dispatched at German embassies; most of them were seconded experts from the BMBF, and the few career diplomats in charge of SD were temporarily appointed. Their assigned role given is to proceed in signing bilateral agreements with local counterparts for research cooperation (Flink & Schreiterer, 2010).

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[13] The FP began in 1984 and is the European Union's main instrument for its common scientific and innovation policy. Its aim is to share costs and pool resources for large-scale projects and to collaborate in finding solutions to European problems. The newest program is Horizon 2020 - the EU Framework Programme for Research and Innovation, which began on January 1, 2014.

[14] Switzerland has been very successful in utilizing this program. For example, under FP6 (2003-2006), there were 1,900 Swiss participants, who secured a total of almost CHF 800 million in funding. Between 2007 and mid-2012 under FP7, Switzerland was the fourth most successful country in terms of approved project proposals (State Secretariat for Education, Research and Innovation, 2015).

[15] The author's interview via email with the former Vice-Minister of the Ministry of Education, Science and Technology in South Korea (March 3, 2015).

[16] Germany has been the largest financer for this regional program, pursuing both promotion and influence goals (The European Commission, n.d.).

Germany began to seriously consider influence-based S&T diplomacy in the late 2000s. After the Federal Government announced Internationalisierungsstragie (The Strategy for the Internationalization of Science and Research) in 2008 to bolster its "2006 High-Tech Strategy",[17]the BMBF vied for leadership in S&T diplomacy. The Foreign Ministry launched its cross-departmental international S&T program, Initiative Außenwissenschaftspolitik (Research Academic Relations Initiative), in 2009. Its aim seemed to be to conduct influence-based S&T diplomacy by engaging international scientific cooperation to work on problems of global reach and by building up S&T capacities in developing countries. However, the BMBF had a different view. Above any other priority, the ministry primarily wanted to use outside knowledge to benefit German research. Access and promotion were key objectives of Germany's global science policy. Since the BMBF was responsible for almost all funds and resources for cooperative R&D programs and S&T diplomacy, it had stronger leverage than the Foreign Office in the policy area (Flink & Schreiterer, 2010).

As a result, a somewhat unique S&T diplomacy moving towards influence-based but still dominated by access and promotion-based aspects has been conducted. As part of the Internationalization Strategy of the German Federal Government and the Federal Foreign Office's Research and Academic Relations Initiative, Deutsche Wissenschafts- und Innovationshäuser (the German Houses of Research and Innovation, DWIHs) was established in 2009. Following the SWISSNEX model, the Foreign Office has opened six centers in New York, Tokyo, São Paulo, New Delhi, Moscow, and Cairoas of 2014, tapping them as a platform for S&T diplomacy. However, due to the lack of sufficient expertise and funds, it is necessary to cooperate with the BMBF and with the Alliance of German Science Organizations consisting of national research organizations and universities (GHRI, n.d.). It is not a surprise, therefore, that the project emphasizes "fostering innovation, improving global competitiveness, and promoting German higher education and science abroad" (Flink & Schreiterer, 2010).

3.3. Japan

Japan has been a traditionally strong S&T country not only with its capacity but also with its S&T diplomatic skills. For example, the International Human Frontier Science Program Organization was founded through Japan's initiative in 1989 in Strasbourg, France, and the Program continues today (HFSP, n.d.). However, the characteristics of Japanese S&T diplomacy are fragmented as each department conducts its own international S&T program.

For example, Japan's official development assistance (ODA) including scientific aid – conducted by the Japan International Cooperation Agency (JICA) under the umbrella of the Ministry of Foreign Affairs (MOFA) – has promoted Japan's image as a generous donor. Since its first S&T agreement with the Soviet Union in 1973, Japan has actively pursued a friendly relationship with other countries through S&T cooperation, indicating the effort of functional diplomacy. As of 2013,

[17] The Federal Ministry of Education and Research, Germany (2008).

Japan under MOFA's leadership had concluded thirty-two agreements of science cooperation with forty-six countries (Sunami, Hamachi, & Kitaba, 2013).

Parallel to the efforts of MOFA, science- and education-related governmental organizations conducted S&T diplomacy for the purpose of access and promotion, particularly in the 2000s. For example, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has implemented the Strategic International Research Cooperative Program (SICP) since 2003.[18] MEXT also launched the Strategic International Collaborative Research Program (SICORP) in 2009 based on intergovernmental agreements on science and technology cooperation. Recently, it launched the World Premier International Research Center Initiative (WPI) to attract frontline researchers from around the world (JSPS, n.d.). In addition, many of Japan's non-university R&D organizations[19] have developed their own global-reach system by dispatching their staff as S&T counselors to embassies and by running their own offices.

In 2008, Japan tried to conduct a more organized and unified S&T diplomacy with an S&T plan proposed by the Council for Science and Technology Policy (CSTP) under the Prime Minister. The plan stated S&T diplomacy objectives as both "to utilize diplomacy for the further development of S&T and promote efforts to utilize S&T for diplomatic purpose" (Sunami et al., 2013, p. 6). However, the tone and the concept of S&T diplomacy at the time were more tilted toward influence-oriented diplomacy, particularly for leadership diplomacy.[20] Based on the CSTP's recommendation in 2008 and for influence-tilted efforts, MEXT and MOFA launched the so-called "Science and Technology Cooperation on Global Issues". This program had two subprograms: the Dispatch of Science and Technology Researchers and the Science and Technology Research Partnership for Sustainable Development (SATREPS). For the former program, MEXT and the JSPS select joint research in developing countries, and scientists were sent to those countries as JICA-affiliated experts. Similar to the first program, the JST and JICA target global challenges – such as limited bio-resources, natural disaster prevention, and infectious disease control – through joint projects with developing countries. While the JST is responsible for domestic research costs, JICA pays for research costs in developing countries (Sunami et al., 2013). In both cases, the Japanese aid agency, JICA, under the guide of MOFA, played a key role in S&T diplomacy while its domestic counterparts were equally strong in leading the direction of S&T diplomacy.[21] Along with this, MOFA-J noted that it would dispatch science and technology officers to twenty-seven overseas diplomatic missions (that did not have a science attaché from the MEXT) "for the first time" (Yakushiji, 2009).

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[18] "This is a 'top-down type' of program that provides support to international research projects with countries and areas and in fields of cooperation designated on the basis of intergovernmental agreements, agreements at ministerial-level meetings, and so forth" (Japan Science and Technology Agency, n.d.).

[19] For example, the Japanese Society for the Promotion of Science (JSPS), the aerospace exploration agency JAXA, the Marine-Earth S&T Agency and the Japan Science and Technology Agency (JST).

[20] See, IWASE (2008).

[21] According to Yakushiji (2009), as of 2009, the number of Japan's S&T agreements with developing nations was a mere 16.7% of the total agreements. The corresponding percentage for the US was 48.6%, for Germany 37.9%, and for France 48.1%. Therefore, the 'Science and Technology Cooperation on Global Issues' was partly to transform 'science aid' into 'science cooperation' with developing countries.

In 2010, a task force team created through a proposal from the CSTP slightly shifted the Japanese position back into more access and promotion-based S&T diplomacy.[22] In 2011, the 4th Science and Technology Basic Plan in 2011 recommended that Japan strategically engage its S&T activities with dynamic developing nations and use S&T to build up the East Asian community (Sunami et al., 2013).[23] Japan wanted to include China, South Korea, and Singapore in the e-ASIA Joint Research Program (e-ASIA JRP) in 2012 as a part of global leadership diplomacy, but Japan's ambition has not been met with commensurate interest from these target countries (The e-ASIA Joint Research Program, n.d.).

In sum, Japan has ambitiously pursued almost every objective of S&T diplomacy but achieved only limited outcomes. Japan's governance for S&T diplomacy is severely compartmentalized. Complaints from MOFA were reported while science-related organizations pursue their own international programs. In 2008, Japan tried to use the top-down coordinating model to overcome this fragmented structure and streamline different organizations into more integrated S&T diplomatic goals. However, this effort does not seem to have produced its desired outcomes yet.

3.4. The United Kingdom

The UK has been an evangelist for modern science, where the Royal Society was formed to openly distribute scientific knowledge and discoveries. The UK was one of the first countries to dispatch science attachés abroad in 1946 to Washington, DC. The UK's R&D system is highly internationalized. The UK is also actively involved in developing countries' S&T projects through the Department for International Development (DFID). Since 2000, the UK's explicitly stated objective for S&T diplomacy is "to influence science and innovation policies of governments, industry and academia to benefit the UK" (Gov. UK, n.d.). Although it did mention other types of goals in external S&T engagements, such as "harnessing international technology partnerships and investment to grow UK innovation capability (Gov. UK, 2014)", the exercise of soft power upon other countries overtook the other objectives (Flink & Schreiterer, 2010).

As S&T diplomacy was directed toward exercise of influence on global issues, the UK's Foreign & Commonwealth Office has increased its leadership. The prior policy of international S&T collaboration and promotion was under the auspices of the Department of Trade and Industry (changed into the Department for Business, Innovation and Skills, BIS). However, "on the bandwagon of Prime Minister Tony Blair's millennium agenda for global change", the Foreign Office triggered the

[22] It stated that, "diplomacy shouldn't just be establishing good relationships with other nations, but should also be achieving the realization of national interests and strengthening the industry's international competitiveness".

[23] Like Germany, Japan after World War II invested significant diplomatic resources in enhancing its international image through scientific aid diplomacy. Particularly, in the late 2000s, Japan was pressured to play a global leadership role as a host for the G8 summit, namely; G8-related ministerial-level meetings and the Tokyo International Conference on African Development IV. But unlike Germany, Japan's declining economy, aging society, and great challenges from rapidly developing neighbors pushed it for towards global S&T cooperation. Japan exhibitss a strong competition "'angst'" due to a rapid rise of Chinese and Korean S&T capabilities (Sunami et al., 2013).

leadership-sharing shift by claiming its responsibility for international influence-based S&T policy (Flink & Schreiterer, 2010). The objective of influence in S&T diplomacy enhanced the Foreign Office's status in international scientific engagements.

As a result, in 2000 the British government launched a cross-departmental S&T program, the Agenda for Global Change, and set up a Science and Innovation Network (SIN). To implement the SIN, the Foreign Office first refurbished its former science counselors' network to accommodate the structural changes in S&T diplomacy. Co-funded by BIS and the Foreign & Commonwealth Office, the SIN, as of 2013, consisted of ninety-three staff across twenty-eight countries and forty-seven cities around the world (UK Science & Innovation Network, 2013). Strikingly, most science officers in the SIN are career diplomats with science degrees, again reflecting the degree of the Foreign Office's involvement in projects (Flink & Schreiterer, 2010). The SIN's officers actively engage with the local science and innovation community in support of UK policy overseas (Gov. UK, n.d.).

However, the leadership of the UK's Foreign Office has declined throughout the decade, and after 2007 it yielded the central role to BIS (Flink & Schreiterer, 2010). The UK's Foreign Office, despite its claim for leadership and influence-inclined S&T objectives, could not lead alone due to lack of sufficient scientific expertise. The UK government announced in 2014 the launching of the Newton Fund, or the Emerging Powers Research Fund, to build S&T capacity in middle and low-income countries. The initiative was not in the hands of the DFID, which was mainly responsible for international aid. The Fund instead consisted of foreign aid financing from BIS and also partly from the country's science budget (UKCDS, n.d.).

In addition, for coordination tasks, the Global Science and Innovation Forum (GSIF) was formed in 2006 led by the head of the Government Office for Science in partnership with various government departments, academic circles, and research institutes. The Forum's major aim was to facilitate coordination of international science and engineering partnerships between government departments, and to provide advice on international S&T policy (NSB, 2008). Each SIN hub was required to set up its own business plan according to its main field of activities under the auspices of the consented agenda in the Forum (Flink & Schreiterer, 2010).

3.5. The United States

Since 1863 when the US Congress passed the Morrel Act to establish the National Academy of Sciences (Wagner, 2008), the US government has actively invested in science and is now at the leading edge of global scientific discovery. The US seeks S&T diplomacy for all purposes categorized in this paper,[24] and there is no country that surpasses its capacity in every dimension of S&T cooperation. Despite this strength, the US government was continuously criticized by academics for its negligence of international S&T cooperation and S&T diplomacy (Ratchford, 1998; National Science Board, 2008; Wagner, 2008).[25]

Traditionally, the DOS had set the overall policy strategy and direction for international S&T diplomacy. Title V of the Foreign Relations Authorization Act, FY1979 (P.L. 95-426), clearly stated

that the DOS was the lead federal agency in developing S&T agreements. As common for every country, security-related S&T issues were coordinated and led by the DOS. A series of agreements between the US and the Soviet Union for scientific exchanges in a variety of fields are good examples of functional S&T diplomacy.[26] The US still conducts functional diplomacy with Iran (Pickett, Leggett & Chu, 2014) and North Korea (Lempinen, 2012) despite their limited achievements.

In 1974, the US 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. It was in response to the rapidly growing importance of global science and environmental issues.[27] In 2000, the US created the new position of an S&T Advisor (STAS) to the DOS (Fedorff, 2009). The STAS provides detailed S&T advice to the Secretary of State, DOS staff, and the director of USAID to enhance S&T literacy and capacity in the DOS (Stine, 2009).[28] The DOS's scientific capacity was bolstered again since the events of 9/11, the Wars in Afghanistan and Iraq, and the IT revolution (National Research Council, 1999).[29] An entirely new type of science counsel system was created after President Obama's speech in Cairo in June 2009. As of 2010, the OES employed approximately 200 staff and serves as a home base for career diplomats who work as science counselors or secretaries at the environment, science, technology and health (ESTH) units in US diplomatic missions (Flink & Schreiterer, 2010). Finally, the US Science Envoy program was launched, and as of 2015 thirteen eminent scientists were appointed for S&T diplomatic missions (The US Department of State, n.d.)

Along with the increase in S&T diplomatic capacity within the DOS, the department has formed an umbrella under which a diverse group of government departments, research agencies, and private organizations operate their own programs and engage in S&T diplomacy. For example, the National

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[24] For example, in 2008, the US Congress stated that the purposes of international science and technology cooperation are : "to strengthen US science by providing its scientists access to the best scientists and research sites around the world; to enable construction of and participation in prohibitively expensive world-class research facilities by partnering with foreign countries to leverage their funds and scientific talent; to address US interests in global matters, such as non-proliferation, water resources, climate change and infectious diseases; to help build technological capacity and address health and resource crises in other countries in order to help maintain US national security and economic interests; and to help build more positive relationships with other countries" (The Committee on Science and Technology, 2008).

[25] This criticism seems to have persisted over the years. In the early 1970s, American scholars claimed that the DOS had not substantially utilized its prominent resources in science and technology for the purposes of US diplomacy. Library of Congress. Congressional Research Service (1976, pp. 1-6).

[26] For example, during the Cold War, the US National Academy of Sciences (NAS), the Department of Energy (DOE), the US Civilian Research and Development Foundation, and the International Research and Exchanges Board (IREX) all conducted S&T cooperation and exchange programs with the Soviet Union organizations. The DOS stood behind all these various S&T networks with the Soviet Union as a leader, facilitator and coordinator (Schweitzer, 2004).

[27] The OES Bureau is responsible for coordinating the formal S&T agreements. As of 2008, there were 39 formal bilateral agreements, most of which were not funded and some of which were inactive (The Committee on Science and Technology, 2008).

[28] The STAS also functions in building partnerships with the outside S&T community both in the US and abroad and shapes global perspective on the emerging S&T developments that may affect US foreign policy.

[29] On the other hand, 9/11 temporarily damaged US promotion diplomacy by triggering the US government to impose a strict visa system to protect homeland security.

Science Foundation (NSF) operates the "Partnerships for International Research and Education (PIRE)" program to support high-quality projects. The Fogarty International Center at the National Institutes of Health has a reputation of funding international research. USAID, an independent federal government agency responsible for scientific aid programs, launched its own S&T program in partnership with other scientific organizations, called "Partnerships for Enhanced Engagement in Research (PEER)".[30] The American Association for the Advancement of Science (AAAS), publisher of Science, has a Center for Science Diplomacy (CSD)[31] and publishes a quarterly journal, the Journal of Science Diplomacy. The organization buttresses S&T capacity in the DOS through its diplomacy fellowships and the Jefferson Science Fellowships. With these programs, the organization annually sends young scientists into the DOS as short-term advisers and practitioners.

It is true that outside of the DOS, the Department of Energy and the Department of Commerce also run their own S&T diplomatic missions within their competence (Kang, 2012). Therefore, even in the science-outsourcing model of the US, exceptional cases are observed. However, overall, the DOS has legal competence in S&T diplomacy and possesses significant S&T capacity to play a leadership role and to outsource domestic S&T communities for its needs.

4. ANALYSIS

4.1. S&T Overview

The countries in this paper are all members of the OECD and equipped with strong S&T capacities and sound R&D policies by which their S&T diplomacy is conducted. As represented in Table 3, the US is a predominant player in the world's R&D activities in total national expenditure: its absolute size in 2012 was about three times that of Japan's and almost four times that of Germany's.[32] The sheer size of US R&D investment indicates its S&T diplomatic ability in seeking every objective ranging from access and promotion to influence. Switzerland seems to be tiny compared to other giant players with its $13 billion in expenditure. However, it is actually the most dynamic country in scientific activities considering its small population; in fact, Switzerland's activities surpass the US's in per capita and are almost threefold of the UK's per capita R&D expenditures. In terms of percentage of GDP, Japan showed the highest level among the compared cases by spending 3.35% of GDP on R&D. In contrast, the UK belongs to a weak group of R&D investment despite its S&T diplomatic influences and well-known internationalized programs.[33]

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[30] The partner organizations include the NSF and the National Aeronautics and Space Administration (NASA), the National Institute of Health (NIH), Smithsonian Institution, the United States Department of Agriculture (USDA), and the US Geological Survey (USGS). USAID is guided by the DOS for its overseas missions and not completely independent from DOS influences (PEER, 2008).

[31] The center was founded in 2008.

[32] The year of 2012 was chosen to compare the selected countries because the data in that year is the latest for all countries that the author was able to obtain from the OECD.

[33] The data in Table 3 does not include the size of public aid diplomacy through S&T.

TABLE 3. Gross Domestic Expenditure on R&D (GERD, 2012) *Unit: $ million, %*

Countries	GERD (current PPP)	GERD as a percentage of GDP	GERD per capita population (current PPP)
Germany	100699.07	2.88	1229.28
Japan	151810.01	3.35	1190.18
Switzerland	13251.40	2.96	1671.09
United Kingdom	38851.82	1.63	609.87
United States	453544.00	2.81	1443.28

Source: OECD Science, Technology and R&D Statistics

4.2. S&T Diplomatic Objectives of Case Countries

All countries pursue almost every objective of S&T diplomacy – access, promotion, public aid, functional and global leadership diplomacy – because these goals are not mutually exclusive but reflect different aspects, and because a country's international S&T policy has overlapping objectives. However, the degree of emphasis is different; while Switzerland heavily pursues access and promotion objectives, the US, with its multiple goals, seeks through S&T cooperation to influence other countries. Based on research findings from Flink and Schreiterer (2010) and the author's additional investigation, Table 4 shows the primary objectives of S&T diplomacy for the selected countries.

TABLE 4. Primary Objectives of S&T Diplomacy

Countries	Primary Objectives
Switzerland	Access diplomacy, Promotion diplomacy, Public Aid diplomacy
Germany	Access diplomacy, promotion diplomacy, public aid diplomacy, global leadership diplomacy (weak)
Japan	Access diplomacy, promotion diplomacy, public aid diplomacy, global leadership diplomacy (weak)
United Kingdom	Access diplomacy, promotion diplomacy, public aid diplomacy, global leadership diplomacy (strong)
United States	Access diplomacy, promotion diplomacy, public aid diplomacy, functional diplomacy, global leadership diplomacy (strong)

Source: Author based on Flink and Schreiterer (2010)

There are a number of reasons why different countries may pursue different primary objectives. The size of R&D expenditure and the consequential limit imposed on capability may determine the type of S&T diplomatic objectives. For example, Switzerland does not often consider exerting influence upon other countries through S&T diplomacy or addressing global challenges. It rather pursues commercial interests and strives to maintain its competitiveness vis-à-vis large-sized advanced economies.

However, size is not the only cause that determines the type of a country's S&T diplomacy. Although the UK's per capita expenditures on R&D is much lower than that of Switzerland and the percentage of GDP is also relatively low, the country actively conducts influence-based S&T diplomacy. The UK's historical role in global politics, foreign policy objectives, and domestic political culture need to be considered in explaining its international S&T behavior. Also, the US may need functional S&T diplomacy more than any other country because of its role and position in the current international system. Aside from its effectiveness, the US is most capable of conduct-

ing influence-based S&T diplomacy. On the other hand, functional diplomacy is not necessary for Switzerland, traditionally a neutral country. Table 5 partially supports the paper's points.

TABLE 5. Resources for Gross Domestic Expenditure on R&D (2012) *Unit: $ million, %*

Countries	Percentage of GERD financed by government	Percentage of GERD financed by industry	Percentage of GERD financed by other national sources	Percentage of GERD financed by abroad	GERD financed by abroad (PPP)
Germany	29.21	66.07	0.39	4.32	4350.20
Japan	16.84	76.12	6.6	0.45	683.15
Switzerland	25.42	60.78	1.73	12.07	1599.44
United Kingdom	28.67	45.61	5.88	19.84	7708.20
United States	30.79	59.13	6.28	3.8	17234.67

Source: OECD Science, Technology and R&D Statistics

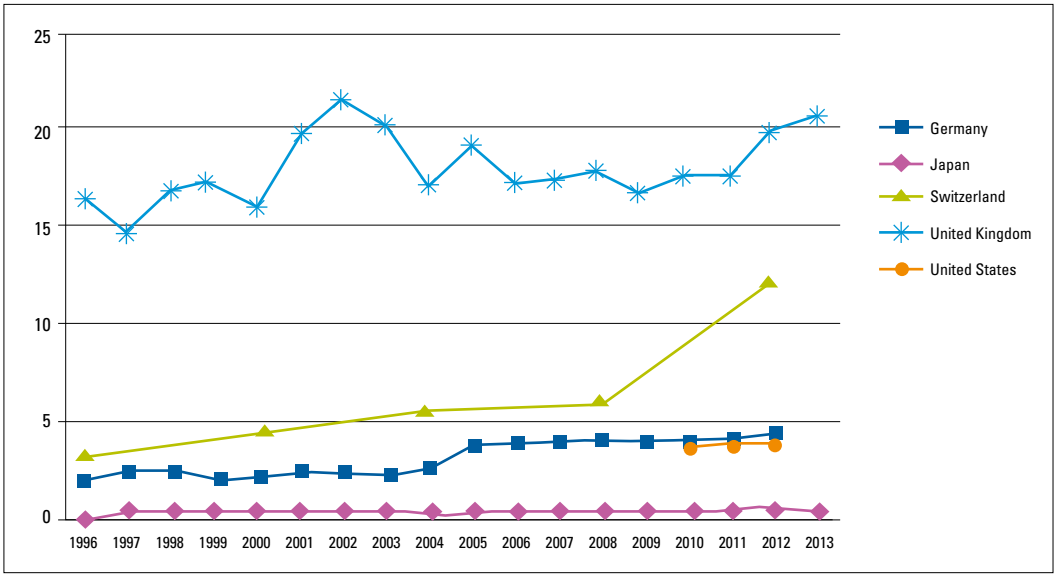
It is intriguing to observe that in 2012 nearly 20% of the UK's domestic R&D was financed from abroad.[34] Following the UK, Switzerland conducted 12%of its R&D activities with foreign resources. In contrast, Japan showed only 0.45% of foreign expenditure invested for its national R&D. In the absolute term, expenditure from abroad was highest for the US because of its large-sized total R&D, and Switzerland's level was about a third of Germany's in monetary terms. However, even with this absolute measure, the UK surpassed Germany, and Japan was recorded as being the lowest among the selected countries, indicating that its R&D resources have not been much internationalized.

Table 5 suggests a partial picture of internationalization, particularly promotion diplomacy, for a country's R&D activities; "partial" here means countries are still able to internationalize their R&D projects through access and influence-based diplomacy with domestic resources while at the same time, promotion S&T diplomacy can be conducted by using domestic resources as well, such as by inviting foreign scientific organizations and personnel. Nevertheless, this data reflects the UK's traditional strengths in international S&T networking and Switzerland's efforts to promote its domestic S&T particularly during the 2000s, thus indirectly supporting the paper's case studies. The internationalization level of the UK's R&D has been continuously high, and the level of Switzerland has increased with its S&T diplomacy in the 2000s and significantly hiked up after 2008 (Figure 1).

Table 6 shows the size of R&D that was streamlined into certain fields (excluding the military sector). The US and the UK heavily invested in their health and environment sectors, which are core global issues. Although the influence of the medical and pharmaceutical industry, domestic environmental politics, and their individual social circumstances need to be considered altogether, their domestic S&T activities are highly aligned with their global leadership objectives. In contrast, Switzerland barely invested in health and the environment but distributed most of its R&D

[34] It is unclear given the OECD data about which type these foreign sources were. Domestic recipients were presumably business enterprises.

FIGURE 1. Gross Domestic Expenditure on R&D Financed by Abroad, 1996-2013 *Unit: %*



Source: OECD Science, Technology and R&D Statistics
Note: the data for Switzerland was collected every four years, and the data from 2010-2012 is only available for the US

resources to non-oriented research. At the same time, universities were major recipients, reflecting a bottom-up approach. German R&D expenditures were well-balanced in each field while Japan's claim for global leadership diplomacy was not verified given the data. This paper argues, therefore, that these two countries' global leadership S&T diplomacy are still weak compared to those of the UK and the US.

TABLE 6. R&D Areas Percentage of Civil Government Budget Appropriations or Outlays for R&D (2012) *Unit: %*

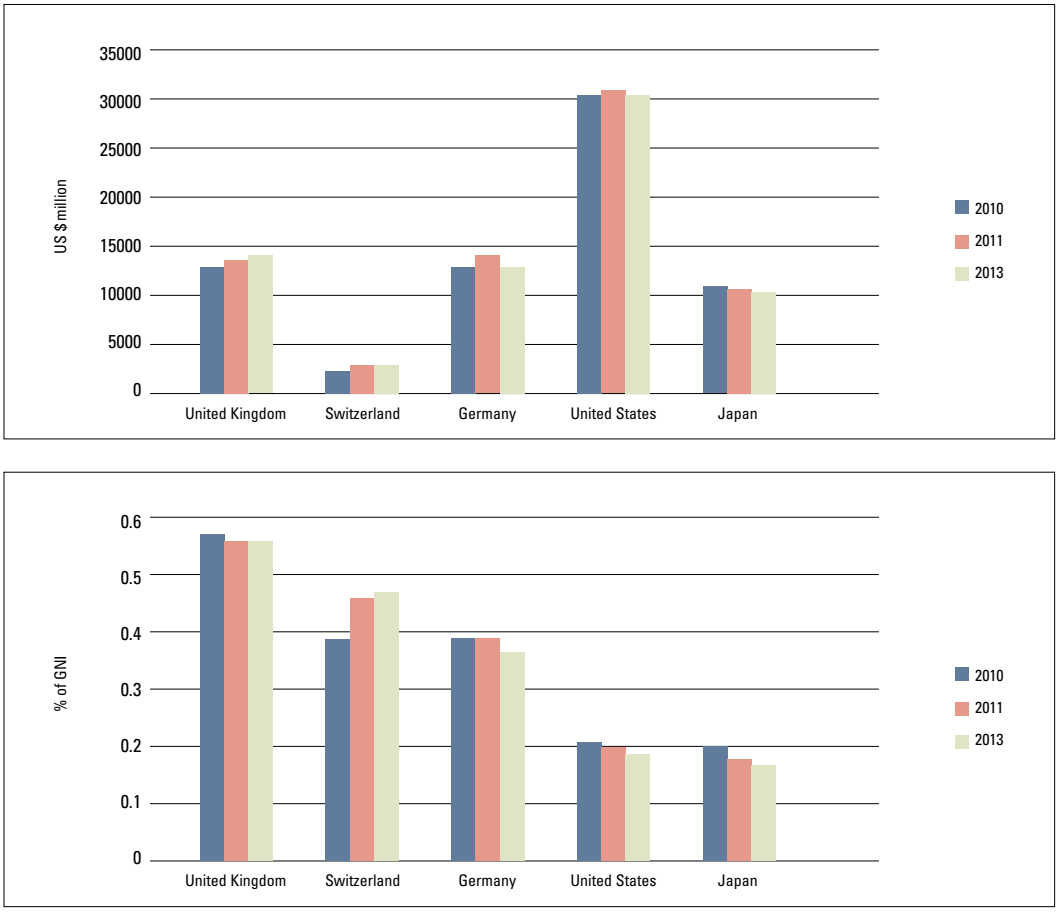
Countries	Economic development	Health and environment	Education and social	Space	Non-oriented research	General university funds (GUF)
Germany	22.29	10.08	4.01	4.89	17.93	41.52
Japan	24.84	8.49	0.65	6.56	21.71	37.75
Switzerland	2.71	0.53	0.7	0	36.32	59.74
United Kingdom	9.68	31.83	4.51	4.1	21.24	28.64
United States	10.4	55.04	1.11	16.6	16.19	0

Source: OECD Science, Technology and R&D Statistics

All the selected countries are assumed to actively conduct public aid S&T diplomacy, bearing in mind their substantial involvement in international development assistance (Figure 2). However, the current international development data published by individual countries or international organizations does not specify S&T-related assistance from non-S&T-related development projects. Figure 2, in this context, roughly supports the view of this paper in that the five countries exert their influence by strengthening the S&T capacities of developing nations. The UK, Switzerland, and

Germany show high percentage of GNI for ODA, and Japan and the US run particular scientific aid programs as in case studies presented above.

FIGURE 2. Official Development Assistance, 2010-2012



Source: OECD International Development Statistics

4.3. Governance

In all selected countries, science-related governmental or quasi-governmental organizations were key players in S&T diplomacy. Also in all countries, aid agencies were actively involved in public aid diplomacy with S&T projects in developing countries. However, this paper divides the selected countries into three primary groups according to a leadership organization for S&T diplomacy: science-centered, science-outsourcing, and top-down coordinating (Table 7).

First, the science-related departments or agencies played a leadership role for S&T diplomacy in Switzerland, Germany, and Japan. The first two countries' recognized S&T programs–SWISSNEX

and DWIHs – were co-funded by science-related departments and foreign affair offices, but final decisions on R&D issues were made by the former while the latter played a role as a facilitator.[35] Japan was slightly different from the former two cases as its S&T diplomacy was accelerated by the CSTP under the Prime Minister in more integrated ways, but MEXT with its partner organizations continued to claim commanding heights for a number of international projects with their own goals.

TABLE 7. Governance of S&T Diplomacy

Countries	Governance model for S&T diplomacy	Leadership/participant organizations
Switzerland	Science-centered	State Secretariat for Education, Research and Innovation/Federal Department of Foreign Affairs, Swiss National Science Foundation
Germany	Science-centered	Federal Ministry of Education and Research/Federal Foreign Office, Alliance of German Science Organizations, German Agency for International Cooperation
Japan	Science-centered/top-down coordinating	Council for Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology/Ministry of Foreign Affairs
United Kingdom	Science-centered	Department for Business, Innovation and Skills/Foreign & Commonwealth Office, Government Office for Science, Department for International Development
United States	Science-outsourcing	Department of State/American Association for the Advancement of Science, National Science Foundation, the White House Office for S&T Policy, Department of Energy

Source: Author

In contrast, the DOS was the official and de facto leadership organization in the US, outsourcing to science-related governmental or quasi-governmental organizations under its umbrella. The presence of OES and STAS in the department clearly reflects that the US DOS possesses significant S&T capacity compared to the foreign affairs offices in other countries. In spite of this fact, the DOS still needs the involvement and assistance of science-related organizations for effective S&T diplomacy.

An authentic top-down coordinating model was not observed in the selected cases. It is true that when the CSTP in Japan pressed for more active S&T cooperation with other countries in 2008, particularly for influence-based diplomacy, interdepartmental cooperation programs were triggered based on its recommendations in the following years. However, this top-down initiative could not completely overcome barriers caused by the compartmentalized structure of Japan's S&T diplomacy. MOFA's role remained still weak while other science-related organizations continued to conduct their own S&T programs overseas.

However, this model is still relevant to the discourse of S&T diplomacy. The US has attempted to institutionalize a unique model similar to this top-down coordinating model. The International Science and Technology Cooperation Act was proposed by a group of Congressmen three separate

[35] For example, in Germany the few career diplomats in charge of S&T diplomacy were temporarily appointed, and the BMBF had "the last say and programmatic expertise" (Flink & Schreiterer, 2010, p. 673).

times. The Act required the establishment of the special committee to be co-chaired by senior level officials from the White House Office for S&T Policy (OSTP) and the DOS to guide US international S&T activities (International Science and Technology Cooperation Act, 2009; 2012; 2014). The OSTP was previously responsible for coordinating S&T activities, but it was believed to be not effective enough to reign each agency following its own goals and priorities (Flink & Schreiterer, 2010). However, this law continuously failed to be passed in the Senate from 2009 to 2014 for financial and political issues. It remains to be seen whether an American top-down coordinating model will emerge in the near future.

The UK case was exceptional and most interesting in that it showed the possibility of a leadership role played by both the foreign ministry and the science-related department. In the UK's SIN, most of the staff were career diplomats with science degree. However, initiatives for international S&T activities after 2007 came from the BIS, and it showed competency not only for access and promotion diplomacy but also for public aid and global leadership diplomacy. In the meantime, the Government Office for Science in the UK, a virtual science department, was only a supporter for the BIS's global outreach.

The relationship between objectives and governance models for S&T diplomacy is not clear given the limited cases. In addition, as mentioned before, the case of the UK prevents this paper from generalizing simple correlation between objectives and governance models. In theory, a science-outsourcing model is likely if countries strive to enhance its S&T aid and functional diplomacy because the active involvement of the foreign affairs department is inevitable. In Germany, Japan, and the UK, leadership conflicts were reported when these countries began to shift toward influence-based S&T diplomacy; DWIHs and SIN were initiated by foreign ministries, and MOFA also announced the dispatch of its own science envoys to embassies that had not been occupied by S&T staff seconded from the MEXT. However, more case studies are required to confirm the tentative findings of this paper.

Lastly, the science-centered model does not necessarily mean that it is a bottom-up approach to conducting S&T diplomacy. In the UK, there was growing uneasiness in scientific communities to see the SIN tilted toward "gaining political influence" while not much caring for "researchers' interests". This is the reason why the Research Councils UK (RCUK) set up their own liaison offices in Brussels, Washington DC, Beijing, and Delhi (Flink & Schreiterer, 2010). Of course, the SIN model was operated in a top-down manner imposed by the foreign ministry. The establishment of GSIF in 2006 did not succeed in subduing the S&T communities' worries, and this incidence was reported also in Germany.

5. CONCLUSION: FUTURE RESEARCH AND POLICY IMPLICATIONS

This paper examined the S&T diplomacy of the five countries whose programs are reputational and being benchmarked by other countries. To conduct a systematic comparison, this study conceptually specified the objectives of S&T diplomacy into two S&T-related goals (access and promotion)

and three political goals (influence through public aid, functional engagement and global leadership). Furthermore, based on a leadership organization, the research suggested three pure governance models for S&T diplomacy: science-centered, science-outsourcing, and top-down coordinating. While this typology is not mutually exclusive in reality and needs to be further examined with more empirical cases, it further illuminates the previous fuzzy concept of S&T diplomacy by providing a new lens of understanding countries' external engagement in S&T.

Nevertheless, the lack of sufficient hard data and of publicity for a country's S&T diplomatic records has limited this study in conducting vigorous hypothetical tests.[36] For example, future research should reveal the cause of different objectives in countries while the relationship between a governance type and a country's objective need to be defined. It is hoped that, in the future study, more data on budget, personnel, organizational structures, strategies, and the locations of external S&T activities for individual countries are secured to assess the nature of S&T diplomacy.

Despite these limits, the following policy implications were found to be generally applicable. First, scientific capabilities are fundamentally important in determining the effectiveness of S&T diplomacy, and for this reason, policymakers need to make an effort to strengthen a country's S&T strengths. There are already useful indicators to measure a country's S&T capacity, such as OECD's Science, Technology and R&D Statistics and RAND's Index of S&T Capacity.[37] The government should enhance the competitiveness of its S&T community both in absolute and relatives terms.

Second, it is equally important to transfer a country's S&T assets into S&T diplomatic assets. The mismatch between a country's internal S&T strength and its diplomatic capability causes the ineffectiveness of S&T diplomacy. While the lack of internationalized S&T activities constrains the advancement of domestic science knowledge, the diplomatic community also may lose an opportunity to utilize science as a tool for alternative engagement. The UK and the US possess more scientific capability in their foreign affairs ministries than those of the other countries. This indicates that countries, in particular, that pursue functional and global leadership should be equipped with sufficient S&T capabilities in their foreign affairs departments. Alternatively, the S&T diplomacy of Germany and Switzerland is led by science-related organizations, and their diplomatic communities efficiently support both outbound and inbound S&T diplomacy. Importantly, as seen in the UK case, a science-related organization is able to internalize a country's diplomatic goals and skills.

Third, the choice of an appropriate governance model is important to conducting successful S&T diplomacy. It is likely that a country has varying types of governance models. A mixed model may be pursued as seen in Japan. Each model has strengths and weaknesses, and leadership competition

[36] The author contacted a number of organizations to obtain hard data on the subject, particularly for budgets, personnel and organizational strategies, but achieved only limited outcomes.

[37] In RAND's report, Wagner, Brahmakulam, Jackson, Wong, and Yoda (2001) developed Index of S&T capacity with seven weighted factors and divided countries into four categories: scientifically advanced countries, scientifically proficient countries, scientifically developing countries, and scientifically lagging countries. However, the Index has not been fully updated since 2001.

sometimes occurs among governmental organizations when specific S&T overseas missions are initiated. The choice of a governance model should not be trapped in institutional path-dependence or domestic politics but designed to satisfy S&T diplomatic missions.

Fourth, countries with less experience in S&T diplomacy but willing to expand international S&T activities can learn from SWISSNEX, the DWIHs or the SIN in the selected countries of this paper. SWISSNEX is an original model, in fact, that influenced the birth of the other two programs. The purpose of SWISSNEX and the DWIHs is primarily for access and promotion-based S&T diplomacy; in contrast, the SIN is mainly to influence other countries. The former two models adopt a strategy of concentration in important cities, while the latter model pursues broad diplomatic networks. Also, SWISSNEX successfully integrates the participation of private sectors and has a bottom-up style. Each country can devise a program that most fits their objectives and domestic circumstances.

Last but not least, the S&T communities should increasingly function at the center of S&T diplomacy. Domestic scientific communities may have different views from the government no matter what the governance model is. Scientists may have their own agenda in engaging international S&T cooperation, but they need their government's support. The Swiss case was the most bottom-up, but the model does not contain influence-based political purposes, and is accordingly limited in its applications. S&T cooperation in the 21st century is evolving into more complex and "self-organizing" networks in contrast to the 20th century's scientific nationalism (Wagner, 2008). In this sense, the concept of "science as diplomacy" (Jang et al., 2012) becomes more relevant than ever and needs to be integrated into policy designs.

REFERENCES

Berg, L. (2010). Science diplomacy network. *Politorbis Nr., 49*(2), 69-74

Fedorff, N. (2009). Science diplomacy in the 21st century. *Cell, 136*, 9-11.

Flink, T., & Schreiterer, U. (2010). Science diplomacy at the intersection of S&T policies and foreign affairs: Toward a typology of national approaches. *Science and Public Policy, 37*(9), 665-677.

Gagnon, M. (2012). *Global health diplomacy: Understanding how and why health is integrated into foreign policy.* (Ph.D Dissertation, University of Ottawa, Canada).

GOV. UK. (n.d.) *UK Science and innovation network*. Retrieved from https://www.gov.uk/government/world/organisations/uk-science-and-innovation-network (accessed on Feb 23, 2015).

Gove. UK. (January 2, 2014). *UK science and innovation network: Working with Korea*. Retrieved from https://www.gov.uk/government/priority/uk-science-and-innovation-network-working-with-korea

Hewitt de Alcántara, C. (1998). Uses and abuses of the concept of governance. *International Social Science Journal, 50*(1), 105-113.

Human Frontier Science Program (n.d.). *History*. Retrieved from http://www.hfsp.org/about-us/history (accessed on May 8, 2015).

International Science and Technology Cooperation Act of 2009, H. R. 1736, 111th Cong. (2009). Retrieved from https://www.govtrack.us/congress/bills/111/hr1736/text (accessed on Feb 23, 2015).

International Science and Technology Cooperation Act of 2012, H.R. 5916, 112th Cong. Retrieved from https://www.govtrack.us/congress/bills/112/hr5916 (accessed on Feb 23, 2015).

International Science and Technology Cooperation Act of 2014, H.R. 5029, 113th Cong. Retrieved from https://www.govtrack.us/congress/bills/113/hr5029 (accessed on Feb 23, 2015).

Iwase, K. (2008). *Science and technology cooperation with developing countries: A key component of science and technology diplomacy*. Retrieved from http://www.jst.go.jp/global/english/ws081008/wspdf/ 03_S1_01.pdf

Jang, Y., Bae, Y., Kim, S., Song, C., Lee, J., Lee, J., Choi, Y., Kim, E., Lee, M., & Jang, S. (2012). *Smart power-based science and technology diplomacy* (in Korean). Seoul: Science and Technology Policy Institute.

Japan Society for the Promotion of Science (n.d.). *World Premier International Research Center (WPI) Initiative*. Retrieved from http://www.jsps.go.jp/english/e-toplevel/, accessed Feb 27, 2015

Kang, J. (2012). *Mid- and long-term master plan for international cooperation of S&T* (in Korean). (Korea Institute of S&T Evaluation and Planning Policy report, 2012-007). MSIP: Gwacheon.

Kim, T. (2012). Paradigm shift in diplomacy: A conceptual model for Korea's "new public diplomacy". *Korea Observer, 43*(4), 527-555.

Lee, S., & Yoon, H. (2012). Korea's global science & technology (S&T) agenda: A study on internationalization of industrial R&D for Korean SME (in Korean). *The Journal of Korean Institute of Communications and Information Sciences, 7*(4), 693-705.

Lempinen, E. (March 28, 2012). Science diplomacy delegation visits DPRK for 'remarkable' symposium on land use and forests. *Targeted news service*. Retrieved from http://www.aaas.org/news/science-diplomacy-delegation-visits-dprk-%E2%80%9Cremarkable%E2%80%9D-symposium-land-use-and-forests

Library of Congress: Congressional Research Service. (1976). *Science, technology, and diplomacy in the age of interdependence*. Washington: U.S. Govt. Print Office.

Lijesevic, J. (2010). *Science diplomacy at the heart of international relations*. Retrieved from http://www.e-ir.info/2010/04/01/science-diplomacy-at-the-heart-of-international-relations/ (accessed on May 1, 2015)

Lord, K., & Turekian, V. (2007). Time for a new era of science diplomacy. *Science, New Series, 315*(5813), 769-770.

Ministry of Science, ICT and Future Planning (2014a). *Science and technology annual report 2013* (in Korean). Gwacheon: MSIP.

Ministry of Science, ICT and Future Planning (2014b). *Implementation planning for the projects of internationalization of science, technology and ICT in 2014* (in Korean). Retrieved from http://www.msip.go.kr/web/main/main.do (accessed on Feb 15, 2015).

National Research Council. (1999). *The pervasive role of science, technology, and health in foreign policy: Imperatives for the department of state*. Washington, D.C.: National Academy Press

National Science Board. (2008). *International science and engineering partnerships: A priority for U.S. foreign policy and our nation's innovation enterprise*. Retrieved from http://www.nsf.gov/nsb/ publications/2008/nsb084.pdf (accessed on Feb 22, 2015).

Nye, J. (2004). *Soft power: The means to success in world politics*. New York: Public Affairs

Nye, J. (2008). *The powers to lead*. Oxford: Oxford University Press

Painter, M. (1981). Central agencies and the coordination principle. *Australian Journal of Public Administration, 40*, 265–280.

Partnerships for Enhanced Engagement in Research (PEER). (n.d.) *Home*. Retrieved from http://sites.nationalacademies.org/ PGA/PEER/index.htm (accessed on Feb 23, 2015)

Pickett,W., Leggett, A., & Chu, P. (2014). Science diplomacy in Iran. *Nature Physics*, *10*, 465–467.

Ratchford, J. (1998). Put science and technology back into foreign policy. *Science, 282*(5394), 1650.

Schlegel, F., Jacot, O., & Fetscherin, M. (2011). Science diplomacy with swissnex China: A swiss nation brand initiative. *Journal of Place Branding and Public Diplomacy, 7*(4), 289–298.

Schweitzer, G. (2004). *Scientists, engineers, and track-two diplomacy: A half-century of U.S.-Russian interacademy cooperation*. Washington D.C.: The National Academies Press

State Secretariat for Education, Research and Innovation (n.d.). *European union framework programmes for research*. Retrieved from http://www.sbfi.admin.ch/themen/01370/01683/index.html?lang=en (accessed on May 8, 2015).

Stine, D. (2009). *Science, technology, and American diplomacy: Background and issues for congress*. (Congressional Research Service, RL34503). Retrieved from https://www.fas.org/sgp/crs/misc/ RL34503.pdf

Sunami, A., Hamachi, T., & Kitaba, S. (2013). The rise of science and technology diplomacy in Japan. *Science & Diplomacy, 2*(1). Retrieved from http://www.sciencediplomacy.org/article/2013/rise-science-and-technology-diplomacy-in-japan

SWISSNEX. (n.d.). *About*. Retrieved from http://www.swissnex.org (accessed on Feb 16, 2015).

The Committee on Science and Technology, U.S. House of Representatives. (2008, April 2). *International science and technology cooperation*. Retrieved from http://www.gpo.gov/fdsys/pkg/CHRG-110hhrg41470/html/CHRG-110hhrg41470.htm (accessed on Feb 15, 2015).

The e-ASIA Joint Research Program. *Home.* Retrieved from http://www.the-easia.org/jrp/index.html (accessed on Feb 23, 2015).

The European Commission (n.d.). *Horizon 2020*. Retrieved from http://ec.europa.eu/programmes/horizon2020 (accessed on Mar 10, 2015).

The Federal Ministry of Education and Research, Germany. (2008). *Strengthening Germany's role in the global knowledge society: Strategy of the federal government for the internationalization of science and research*. Retrieved from http://www.bmbf.de/pubRD/Internationalisierungsstrategie-English.pdf (accessed on Feb 16, 2015).

The German Houses of Research and Innovation (GHRI). (n.d.). *Home.* Retrieved from http://www.germanin novation. info (accessed on Feb 16, 2015).

The Organization for Economic Cooperation and Development (OECD) (n.d.). *Science, technology and R&D statistics*. Retrieved from http://www.oecd-ilibrary.org/science-and-technology/data/oecd-science-technology-and-r-d-statistics_strd-data-en (accessed on May 1, 2015)

The Organization for Economic Cooperation and Development (OECD) (n.d.). *International development statistics*. Retrieved from http://www.oecd.org/dac/stats/statisticsonresourceflowstodevelopingcountries.htm (accessed on May 1, 2015)

The Royal Society (2010). *New frontiers in science diplomacy: Navigating the changing balance of power* (RS Policy Document 01/10). Retrieved from http://www.aaas.org/sites/default/files/New_Frontiers.pdf (accessed on Feb 14, 2015).

The U.S. Congressional Budget Office (CBO). (2009). *International science and technology cooperation act of 2009*. (H.R. 1736). Retrieved from http://www.cbo.gov/sites/default/files/hr1736.pdf (accessed on Feb 23, 2015).

The U.S. Department of State. (December 4, 2014). *Announcement of science envoys*. Retrieved from http://www.state.gov/ r/pa/prs/ps/2014/12/234682.htm (accessed on Feb 23, 2015).

The White House. (2009). *Remarks by the president at Cairo university, 6-04-09*. Retrieved from http://www.whiteHouse.gov/the-press-office/remarks-president-cairo-university-6-04-09 (accessed on Feb 15, 2015).

UKCDS (2014, April 24). *Newton fund: £375m for international science partnerships*. Retrieved from http://www.ukcds.org.uk/news-events/news/newton-fund-375m-for-international-science-partnerships

UK Science & Innovation Network. (2013). *UK science and innovation network report.* Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/267820/bis-13-1331-uk-science-and-innovation-annual-report.pdf

Wagner, C. (2008). *The new invisible college: Science for development*. Washington, D.C.: The Brookings Institution.

Wagner, C., Brahmakulam, I., Jackson, B., Wong, A., & Yoda, T. (2001). *Science and technology collaboration: Building capacity in developing countries?* (RAND MR-1357.0-WB). Retrieved from http://www.rand.org/content/dam/rand/pubs/monograph_reports/2005/MR1357.0.pdf

Yakushiji, T. (2009). The potential of science and technology diplomacy. *Asia-Pacific Review, 16*(1), 1-7.