Feature Article on Scientific Advice: Paradigm Shift in Scientific Advice

Responsible Innovation, Post-Normal Science, and Ecosystemic Approach

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Growing expectations and skepticism about "scientific advice"

"Scientific advice," which provides the government, corporations and individuals with useful technical information, knowledge and judgments on the policy issues related to science and technology, such as "risk" issues in food safety, emerging infectious diseases, climate change, earthquakes, nuclear power and cyber security, and as promotion of science, technology and innovation, is expected to play an increasingly vital role in contemporary society.


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Scientific advice in Japan has hitherto been undertaken by various deliberative bodies and organizations, including councils and committees attached to government ministries and agencies, regulatory bodies such as the Food Safety Commission, and, regarding comprehensive policies for the promotion and regulation of science, technology and innovation, the Cabinet Office's Council for Science, Technology and Innovation (CSTI) and academic organizations such as the Science Council of Japan (SCJ). In addition, since the Great East Japan Earthquake and the Fukushima Daiichi nuclear disaster, a plan to introduce the system of "science and technology advisers" has been under examination in order for them to advise the prime minister and other ministers on both the promotion of innovation and emergency response in the event of disasters such as a nuclear accident, and to communicate a unified scientific view on the topic to the public.

This system is based on the model of Chief Scientific Advisers (CSAs) in the United Kingdom. Similar posts are also now in place in New Zealand, Ireland and the Czech Republic, and in 2012, the European Union also appointed a CSA to the President of the European Commission. In the United States, in addition to the advisory bodies such as the Office of Science and Technology Policy (OSTP) and the President's Council of Advisers on Science and Technology (PCAST), the President is advised by the Science Adviser to the President and the Assistant to the President for Science and Technology. Last fall, the United Nations established the UN Scientific Advisory Board, consisting of twenty-six eminent scientists in natural, social sciences and humanities, including a Japanese scientist, Professor Reiko Kuroda, Tokyo University of Science. The Board's mission is to provide advice on sustainable development to the UN secretary-general and to executive heads of UN organizations. An international conference Science Advice to Governments: A global conference for leading practitioners, is due to be held in New Zealand in August this year.

Amid such great expectations and moves to establish new systems around the world, the validity and reliability of scientific advice has come under increasingly severe scrutiny. The real policy issues that require advice are so complex that the advice frequently involves many uncertainties, and that expert opinions are also often divided. It is also not uncommon that the advice is influenced by the social, ethical values of individual advisers (scientists) and their research fields and by the political and economic interests of specific research fields and social groups. In post-March 11 Japan, for example, it more or less stands to reason that the conclusion of advice differs significantly depending upon who sit on the energy policy committee.

Under such circumstances, what steps should be taken to improve and establish systems and practices for producing scientific advice that is not only scientifically reliable in its substance but also socially trustworthy? This is a vital challenge all over the world, including the United Kingdom which first created the CSA post, and Japan has also been taking steps since March 11, with the Japan Science and Technology Agency Center for Research and Development Strategy (JST-CRDS) producing "Toward the Establishment of Principles Regarding the Roles and Responsibilities of Science and Government in Policy Making" in March 2012 and the SCJ publishing "Code of Conduct for Scientist: Revised Version" in January 2013. In this paper, I would like to propose three paradigm shifts as necessary requirements (functional requirements) for reliable and trustworthy scientific advice, aiming to supplement the domestic argument about introducing science and technology advisers in Japan.

Extension to "responsible innovation"

My first proposal is that the scientific advice given from now on — even if, or rather precisely because, it is advice for promoting the research and development (R&D) of science and technology, the dissemination of its outcomes, and "innovation" intended to create economic and social benefits — must be integrated with "regulation" to prepare for and cope with various problems, including the risks associated with innovation (public health, environment, security, etc.), accident response and ethical problems, and "communication" activities conducted among diverse people, organizations and groups, via various channels, and in various forms. More specifically, following activities are required.

First, regarding the relationship between innovation and regulation, regulatory practices must start from the upstream phase of R&D process. From the early stage of the technology, it is necessary to progressively repeat the practices of technology assessment (TA) that prospectively assess the technology's potential future impacts on society and trade-offs between risks and benefits and that feed back these findings to the planning at each step of R&D process and the design of related institutions. In other words, this is an integration of two policy functions, the promotion and the regulation of science and technology, into their R&D process. Traditionally, TA has been plagued by the "Collingridge dilemma," which means that until technology is fully developed and widely used, its impacts cannot be sufficiently predicted (an information problem) but that once technology has diffused in society to the extent that its impact can be predicted, it is then difficult to change the way in which the technology is developed and used (a power problem). The TA practices mentioned above would mitigate the power problem through involvement from the upstream stage of R&D and would also help mitigate the information problem through the progressive repetition of assessment conducted alongside the development of the technology.

As for the relationship between innovation and communication, a broad range of actors are to participate in this process, including researchers involved in the R&D and future use of its results, government, industrial sectors, potential stakeholders likely to be affected by the technology, the general public, NGOs, and researchers in social sciences and humanities who are familiar with the social impacts of the technology. In this process, the assessment covers not only the impacts on the economy, human health and the natural environment but also the effects on social institutions, lifestyle, work, values and suchlike. Moreover, it also examines the validity of various social and cultural assumptions embeded in the design and course of development of the technology including the purposes, intent, motivations of conducting the R&D in the first place, and the underlying social expectations and values from the perspective of a wide range of people. Such publicly open examination of the driving purpose of R&D is called "democratic governance of intent" in the sense that it opens up the space of making decisions in relation to the purposes and intent which has been traditionally closed within the circles of policy makers and representatives in science and industry.

Various methods such as the real-time TA and the constructive TA have been developed in the United States and Europe as the methodology for the type of TA described above and in some cases they have been applied to the R&D of emerging science and technology such as nanotechnology.

While TA practices are intended for specific technologies and research areas, there are other types of activities such as "foresight," which involves exploring the future possibilities and prospects of society and technology in a wider context and feeding its results into the planning and prioritization of R&D themes that are worth pursuing and the formation of related policies. While some approach this from the "supply side" of science and technology, with the seeds and themes of current and future R&D, the more common approach is to start on the demand side with social problems and explore what R&D projects are necessary to solve them. In the United Kingdom, which has been engaged in foresight since 1994, the Government Office for Science, working with the Department for Business, Innovation & Skills, is in charge of implementation and takes social issues over the next ten to one hundred years as its starting point.

Furthermore, in recent years, the concept of "Responsible Innovation (RI)" or "Responsible Research and Innovation (RRI)," which combines the ideas and practices of TA and foresight, has also been attracting attention. The concept emerged in the early 2000s and, in Japan, the need for "responsible innovation" was pointed out in a report issued in 2007 by the Industrial Science Technology Policy Committee of the Industrial Structure Council, METI entitled "The Key to Creation of Innovation and the Promotion of Eco-innovation." Recently, RRI has become a key concept in the EU's innovation strategy. Von Schomberg defines RRI as follows: ""A transparent, interactive process by which societal actors andinnovators become mutually responsive to each other with aview to the (ethical) acceptability, sustainability and societaldesirability of the innovation process and its marketable prod-ucts (in order to allow a proper embedding of scientific andtechnological advances in our society) ."

Stilgoe et al define RI more simply, stating, "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present," and point out the following four dimensions that constitute RRI: (i) anticipatory — anticipating the intended and unintended consequences of the innovation; (ii) reflexive — reflecting on underlying purposes, motivations, and potential impacts of innovations, what is known and what is not known; relevant uncertainties, risks, areas of ignorance, assumptions, questions, and dilemmas; (iii) deliberative — opening up a broad scope of visions, purposes, questions, and dilemmas of innovations through inclusive deliberation among the general publics as well as diverse stakeholders; (iv) responsive — using these processes to set the direction of innovation. From now on, scientific advice must be positioned within such a RRI framework.

From "Positivism" to "Post-Normal Science"

The second paradigm shift towards reliable and trustworthy scientific advice is a shift in understanding the relationship between science and policy making from "Positivism" to "Post-Normal Science (PNS)."

For the purposes of this paper, "Positivism" refers to the following type of viewpoint: (i) fact findings through science can be achieved in a value neutral manner, independently of social and political interests and value judgments; and (ii) political decision making and consensus building are made possible through such objective and certain knowledge of the scientific facts.

Such a view of the science-policy interface appears reasonable, but there are in fact many problems. This is because the "reality" in which the practice of scientific advice is situated, that is, scientific uncertainties and the complexity of the problems of values and interests, ends up being covered and hidden. Pielke, who calls the positivist view of the science-policy interface the "linear model," points out that scientific advice based on a particular value assumption and policy recommendations based on such advice tend to end up being disguised as objective, neutral and fair advice and recommendations.

In fact, the problems faced by policy-makers are complicated, and they are not necessarily problems that can be solved by simply applying existing theories, methodologies and findings. There are various uncertainties arising from a lack of knowledge, measurement error, modeling (simplification) or the stochastic nature of the object itself and there may also be unknown unknowns which mean we don't know what we don't know in the first place. There are some situations of "indeterminacy" where the framing of the problem, for example, what type of problem it is, which factors and conditions are relevant, and the which fields of knowledge should be used, is not determined. There are other situations called "ambiguity" where the framing, the meanings of concepts and terms, the structure of the causal model, the assumptions, the burden of proof, the type of evidence required, definitions of measured variable, the choice of methods and conditions of experiment and measurement, the interpretation of data and so on and so forth vary among experts and other stakeholders.

The problem of values and interests is also complicated. Firstly, social decision-making such as policy-making involves problems that cannot be resolved through science alone. For example, judging the order of priority and trade-off, i.e. choosing what to protect and what to sacrifice, is fundamentally a matter of value judgment. While these problems relate to science, they are by nature problems that require agreement and consensus building on the part of the stakeholders, which cannot be left to science.

Secondly, scientific judgments and value judgments cannot be separated so easily. As explained above, a scientific judgment is sometimes accompanied by large uncertainty that cannot be ignored and, if the judgment made is regarded as being disadvantageous for a specific social group or organization, the uncertainty is made into a political issue. To protect their own interests, they refuse to accept inconvenient scientific claims on the grounds of uncertainty and, even if new evidence is obtained, they play the card of uncertainty time and time again, preventing a solution to the problem from being reached. Without looking back at the history of Minamata disease, such cases of political abuse of scientific uncertainty are too common to enumerate in Japan and other countries around the world.

Even if not in so outspokenly deliberate manner, dealing with uncertainty tends to take on political meanings. Millstone et al point out that, in an additive risk assessment by the Joint FAO/WHO Expert Committee on Food Additives, there was an implicit bias in the burden of proof. While the research findings showing that there is no adverse effect are accepted at face value, stringent additional tests are required for findings that show an adverse effect. Needless to say, this implies, even if unintentionally, that the risk assessors are prioritizing the profits of the companies that manufacture and sell additives over the health risks to consumers. There are many other factors besides uncertainty that can have political significance.

This complicated relationship between science and politics is difficult to understand using the positivism model. New alternative views are required and one of them is PNS proposed by Ravetz and Funtowlcz. According to this model, approaches to problem-solving using science are categorized according to two measures: “Systems Uncertainties” and “Decision Stakes,” as shown in the figure. Systems uncertainties include not only uncertainties inherent in science as explained above but also uncertainties in predicting and controlling the behaviors of systems such as politics and economics that interact with science, and “ethical uncertainty”, i.e. diversity and variations in values as to science and technology. According to Ravetz et al, problems where uncertainties and decision stakes are both small can be addressed by means of “normal science” (or applied science) which applies existing scientific knowledge and methodology. The positivism model is the equivalent of this. However, when handling a problem where one or both of the measures are medium, by-the-book solutions are not enough and it is the turn of “Professional Consultancy,” which relies on skills and judgment mastered through experience as a professional and insights according to the circumstances. Moreover, if handling a problem involving a high degree of uncertainty or strongly opposing values and interests, then a PNS approach is required. This involves not only dealing with quantitative and qualitative uncertainties in science but also deliberation by “extended peer communities” including stakeholders as well as scientific experts.

This PNS approach is not simply an academic or theoretical approach but has begun being applied in policy measures. For example, Petersen et al produced guidance for the assessment and communication of uncertainty and for the stakeholder participation based on PNS theory and methods and applied them in practice at the Netherlands Environmental Assessment Agency.

In Japan, as mentioned earlier, the principles and code of conduct produced by the JST and SCJ have been produced. In the future, it will be necessary to establish guidance and methodologies that can be used on a practical level and to build capacities of researchers and secretariat staff at organizations in charge of scientific advice. It goes without saying that this must incorporate not only contributions from natural science and engineering but also those from humanities and social sciences in order to examine the social and normative problems associated with science and technology and scientific advice.

(1) High
(2) Decision Stakes
(3) Post-Normal Science
(4) Professional Consultancy
(5) Normal Science
(6) Low
(7) Systems Uncertainties
(8) High

Shift from "hero model" to "ecosystem" model

The third paradigm shift is the shift from the "hero model" to the "ecosystem model" of scientific advisers.

The discourse surrounding scientific advice is frequently accompanied by a type of scientist image that could even be referred to as the "hero model" or the "saint model." It is a scientist image that the effectiveness and reliability of scientific advice is ensured by means of outstanding individual qualities, including distinguished expertise and erudition, honesty and openness, and neutrality and impartiality. It is, of course, desirable that advisers have such qualifications as far as possible. However, advice will not function on the strength of these alone. Mulgan, who himself has been involved for many years in works related to scientific advice both inside and outside the UK government, says that "The effectiveness of advice doesn't depend greatly on the cleverness of the person giving the advice or even the logical cogency of their arguments." Moreover, like the positivism discussed earlier — indeed the hero model is the individual version of positivism — there is also the risk that the political nature of the scientific advice will end up being covered and hidden by this image.

What steps should be taken to avoid problems like these and to ensure the effectiveness of scientific advice? Here the focus of attention needs to be the "ecosystem" that makes the scientific advice possible. According to Doubleday and Wilsdon, this is "a rich ecosystem which includes analytical professionals within the civil service, external advisory committees, policy 'tsars', national academies, learned societies, universities, NGOs and civil society organizations — and many others." Below I attempt to examine the elements and functions necessary for such an ecosystem in three dimensions: (i) individuals, (ii) organizations and networks, and (iii) society and culture.

Firstly, an important element for the individual dimension is, according to Mulgan, the role of adviser as "mediator" or "broker," for which, besides a high level of expertise in his or her own field, the adviser needs the ability to translate, aggregate and synthesize the knowledge and information from a broad range of other fields. The type of problems that become policy issues require a broad range of scientific disciplines so that no scientist can by him/herself supply expertise and make expert judgments on everything about the problem. He or she must inevitably collaborate with prominent researchers in other fields. The individual qualities required here include knowing or being able to guess what specialties are necessary to address the problem, who the prominent researchers in these fields are and which research organizations are suitable for making inquiries with. This is especially important when an individual scientist has to handle a wide range of issues as in the CSA system of the United Kingdom, but this may also be required of members of deliberative bodies like the CSTI in Japan, which similarly addresses a wide range of issues. Furthermore, for advice to be effectively utilized in policy making, it is also important to understand "advice needs," for example, what kind of problems the policy-makers are faced with and what kind of advice they need, and to grasp the plan and schedule of policy making in ministries and agencies.

Next, for the organization and network dimension, broadly speaking, there are two requirements. The first is to attach importance to the following three functions as those of organization and network for deliberation among fellow advisers or by groups of experts that support the advisers. The first function is, needless to say, the function of gathering experts from various fields relevant to the issue in question in order to enhance the quality of the advice. In the United Kingdom, there is the Government's Chief Scientific Adviser (GCSA) who advises the Prime Minister and the Chief Scientific Adviser's Committee (CSAC) comprised of CSAs (currently 21) attached to each ministry and agency. Likewise in Japan, upon introduction of the science and technology adviser system, it will no doubt be necessary to establish some conference body equivalent to CSAC.

The second key function of the adviser's organization/network is to hold much debate, accumulate and update knowledge on various topics in normal times in preparation for emergencies, and to find experts suited to address the problems in question and develop an extensive network of them. Following the Fukushima Daiichi nuclear disaster, the question of how to produce the "unique voice" of a group of scientists (consensus between scientists not limited to one view but also incorporating minority views) in an emergency has been the subject of debate. When it comes to building such a consensus, it would be of great help if the reports on which a consensus has been reached through debate in normal times are available. Of course, in emergencies, responses suited to the occasion are required, but the buildup of experts in normal times must surely be helpful for securing experts who can be entrusted with such judgments. It is expected that the SCJ will play a vital role in doing such an activity.

Another important function of adviser's organization/network is to balance at an organization level the bias of advisers with regard to interests and values, which means adopting "realism" with respect to bias. In other words, assuming that "there is no such thing as an unbiased expert" and, rather than demanding neutrality from individual experts, the organizer ensures the neutrality of the adviser organization as a whole by means of achieving balance by collecting people with various biases. The neutrality is collective property and built on the plurality of viewpoints. For example, U.S. National Academy of Science has a detailed guidance for the balanced selection of members and conflicts of interest.

In addition to key functions of adviser's organizations and networks like those described above, another key requirement at an organization and network level is improvement of the expertise of the secretariat of the organization that supports the advisers. Important for this is not only the expertise necessary for conducting research and analysis, but also the skills of translation, aggregation and synthesis of knowledge and information from a wide range of fields just as the advisers do. Furthermore, the secretariat staffs need to have knowledge and knowhow about addressing uncertainties of science and involving stakeholders, as well as management skills regarding member selection and operation of the adviser's organizations and networks. Recently, to strengthen the its function as a "Control Tower" of science, technology and innovation policy, the CSTI has just created a new system of the Science and Technology Policy Fellow, appointing around ten younger researchers in universities and other research institutions as the research and analysis staffs to its secretariat. In the future, however, this is likely to be insufficient. In relation to the science and technology advisers system that Japan plans to introduce, this point is worrying. Even in the case of the SCJ, the secretariat has virtually no research and analysis capability. These secretariats need to be strengthened and at the same time to extend and utilize the networks of researchers and organizations outside of government such as universities and independent administrative research institutions, academic societies and private think tanks. MEXT has launched the "Science of Policy in Science, Technology and Innovation Policy (SciREX)" program. In the future, it will no doubt be necessary to promote the accumulation of scientific knowledge and the creation of networks of researchers from a cross-ministerial perspective by utilizing the SciREX and other framework of research grants and contract research offered by various ministries and agencies. Another idea is for the SCJ or the National Diet Library to also establish some kind of research grants/contract research program, either independently or in collaboration with existing funding agencies.

Shift to a society that demands evidence

Finally, let me conclude this paper by pointing out two requirements for the socio-cultural dimension of the scientific advice ecosystem.

The first is "plurality of knowledge sources" and this has various effects. It promotes reciprocal checks and balances in relation to knowledge claims and also enables "triangulation of trust" which means that, if the scientific findings and judgments of independent, mutually critical knowledge sources coincide, then their claims are more reliable and credible from a third-party perspective. Also, the results of studies, such as "cost estimation of various power generation methods," vary depending on who performed the calculation, but this is not necessarily a negative outcome. There is also an advantage that comparing the different results makes it is easier to understand the effects of the differences in assumptions and parameters of each estimation and to grasp the whole picture of the problem. In order to enhance such effects of the plurality of knowledge sources, it is necessary to enrich the ecosystem of scientific advice. Within and around government, there are already various knowledge sources such as the CSTI, science and technology advisers, various councils, etc., the National Diet

Library, the SCJ, private think tanks as well as groups of researchers that belong to universities and independent administrative institutions, but, from now on, the activities of non-profit think tanks and suchlike based on the civil society also need to be vitalized.

Another requirement is the fostering of a "culture that demands evidence" not only by government but by society as a whole. The expected effect of doing so is not limited to the improvement in the quality of policy content at the time of policy formulation. It is also expected that ex-post-facto verification and evaluation, including those done by the third parties independent of the government, would be possible and this could lead to improvement in policy. Also, if the occasions in which evidence is required in decision making increase, the demand from government, etc. for policy analysis and research and the circulation of capital would also be expected to grow and to lead to increased employment of researchers, resulting in improvement of their competence. It will be good if in civil society as well there is a build-up of capital for generating evidence through donations and cloud funding to non-profit think tanks and NPOs, etc.

The United Kingdom-based charitable trust Sense About Science carries on the Ask for Evidence campaign where people urge enterprises, politicians, government and experts to explain the evidence of the claims they make regarding health and environmental problems, etc. Changing a culture is not an easy task but it will be good if civil society initiatives like this increase in Japan as well. This would surely contribute to improving the transparency and accountability of government, corporations and expert communities with regard to evidence.

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