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—Innovation and Society—

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Introduction

The development of science and technology is accompanied by various risks and social problems, as well as benefits. As the scope of this issue has grown wider, the range of interested actors has increased accordingly (Shiroyama, 2007).

For example, the development of nuclear physics and nuclear energy technology has had the benefit of securing sources of energy, but it has also been accompanied by constant safety risks and the security risks of nuclear proliferation. Alternatively, the development of life sciences and genetic engineering has raised issues of safety and ethics, and there is particularly strong awareness of these issues in regard to experimentation in gene therapy—the genetic manipulation of human beings. Moreover, science and technology that is pervading society—such as genetically modified crops—is being assessed by a variety of actors and from diverse points of view, such as the perspective of economic efficiency, in a manner that goes way beyond purely scientific and technological logic.

Despite the fact that scientists would brand this talk as irrational and akin to vicious harmful rumor, if this is the reality of society, the escaping from the use of specific technologies to avoid economic loss is highly rational as far as society is concerned (for example, for agricultural producers and agricultural policy makers).

So far as society decides to make use of science and technology with diverse social implications that encompass risk for society as well as benefit, there is a need for systems throughout society for the management of the development and utilization of science and technology. In other words, governance of science and technology is required.

The following sections outline how the governance of science and technology might be organized and then set out the functions that are required of it.

What is Governance of Science and Technology?

Science and technology have many implications for society. For this reason, society has to form an assessment based on the various problems and points for deliberation that exist at the borders where society meets science and technology. This function of societal assessment will require certain mechanisms, and to cope with the various issues, a specific style of institutional design will be vital. These mechanisms and specific institutional design are what constitute the governance of science and technology. A variety of actors, such as experts in various fields, various levels of government (international organizations, national government, and local government), various groups (such as professional groups and employers' associations), and citizens will then collaborate and share the effort in the governance of science and technology, and—while they will sometimes come into conflict—they will manage the various problems at the borders where society meets science and technology.

Governance and traditional government are often thought of as opposing forces. Government is taken to mean the official institutions for governing, while governance is understood as encompassing a wide range of systems—including customs of society and markets—that are outside the official institutions of government, i.e. "the whole range of institutions and relationships involved in the process of governing" and "self-organizing, inter-organizational networks" (Rhodes 1997). Whereas the organization of government is based on an internal vertical hierarchy, governance allows for structures that include horizontal relationships between entities such as various societal groups and companies, and between various levels of government.

A wide range of actors has come to be involved in science and technology, in reaction to the numerous social implications of science and technology in specific societal contexts. Scientists and engineers also have a major role as individuals and are building various independent professional organizations. The role of companies in the introduction of technology to society is also significant. In recent years, companies have also played a noteworthy role through CSR (corporate social responsibility). On the other hand, at government level, while standardization is playing a major role at the international level, there are many matters that the national government and local governments must deal with in accordance with local conditions. Thus, it could be said that within the domain of science and technology, there is more of an appearance of governance than government.

Functions of Governance of Science and Technology —Requisite Elements of Societal Judgement

Risk management

Clarifying risks and benefits

The development of technology can entail an increase in various risks as well as various benefits. To cope with this state of affairs, risk assessment and risk management are being attempted by various segments of society (Shiroyama, 2007).

Risk assessment generally involves multiplying the probability of the occurrence of damage by the scale of the damage. Scientific knowledge based on immunological data and animal test data is essential for this assessment. As a matter of course, the scope of risk assessment can vary greatly, according to whether it is based on the number of dead or on the number of victims (such as the sick and injured), and on whether a qualitative distinction is drawn between large-scale catastrophic disasters and smaller disasters. On the other hand, risk management refers to the activity of deciding where to draw the line and what level of risk to allow—based on the risk assessment—before proceeding with the overall project.

When taking risk management decisions, it is necessary to consider how the risks are balanced by the benefits of the technology concerned. Without taking this factor into account, it would be impossible to understand why the car—which risk assessment regards as entailing a high level of risk in numerical terms—is accepted by society. When the benefits are assessed, the question of distributive implications (that is, to whom do the benefits accrue) is also important. Society may reject a certain technology, even if the overall benefits are considerable, if the benefits are directed mainly towards a certain sector. It is recognized that society has not readily accepted nuclear power generation or genetically modified foods—despite the fact that their risks are assessed as low. One reason that can be cited for this is that it is corporations who are the direct beneficiaries of these technologies (in terms of perception, at least).

Often, some risks are ignored or exaggerated. When a company engages in technological development, it is possible that it will not publicly disclose the relevant risk information—even if it is aware of the risks that accompany the technology —out of consideration for its return on investment from the development of the technology. When a company conducting technological development on site fails to disclose information, it is extremely difficult—at least in the short term—for society to obtain this information separately and independently. On the other hand, the main thrust of opposition to a particular technology (which may even emanate from a competing company) may exaggerate some of the risks. The problem in this type of situation is how to conduct comprehensive and balanced risk mapping. For the experts too, the perceived areas of risk vary between different specialist fields.

Benefits too can be inadequately presented or exaggerated. In the cases of genetic modification technology and nano-technology, it is a long way from these technologies to concrete benefits for society. Certainly the arguments can be made that the introduction of genetically modified crops will allow increased volumes of food in developing nations, which will alleviate poverty, or that the introduction of medical diagnostic technology employing nano-technology will enable preventive medical care based on simple continual monitoring, leading to reduced medical costs. However, there are a number of variables external to the introduction of a technology that must come into play in order for its effectiveness to be realized. Thus, technology developers are discontented, because when a technology is assessed, the risks alone are adequately addressed while the benefits are not. On the other hand, technology developers tout the effectiveness of a technology in their quest to obtain research funding, and it is claimed that—as there are many variables in play that influence its effectiveness—they are apt to exaggerate the effectiveness.

Moreover, there is uncertainty over both risks and benefits. This represents both uncertainty over scientific understanding, as mentioned earlier, and uncertainty over utilization of the technology.

As regards expectations of risk assessment from science, society often expects a definitive answer, despite the fact that, as mentioned previously, science comprises a degree of uncertainty. It is of course possible that the uncertainty will recede as science progresses; however, it will be difficult to eliminate it completely. For society, the question thus arises of how to assess a certain acceptable level of uncertainty. The choice between the “precautionary principle” or the “no-regret policy” expresses the difference in attitudes to this uncertainty. The precautionary principle refers to the attitude of taking preventive control measures (even while uncertainty remains as to whether anything will happen), because if something does happen, the resulting damage will be enormous. In contrast, the no-regret policy refers to the attitude of taking only meaningful precautionally measures (even if nothing is going to happen), instead of reacting during the period of uncertainty on the assumption that something will happen. Which of these two attitudes to select is a policy selection problem for society.

There is also uncertainty over benefits. As mentioned earlier, one of the characteristics of technology is that it can be used for numerous purposes. There are also many technologies that are used in ways that differ from those envisaged by their developers. There are also technologies that are used in a manner quite distinct from their original purpose. Technology developers also sometimes advance the argument that, although in the initial experimental stage of any technology it is easy to foresee certain risks, the eventual actual benefits do not become clear until some time has passed (particularly in the case of revolutionary ground-breaking technologies), and that at the outset it is very difficult to explain the benefits, even if asked to do so. However, it should probably also be acknowledged that there are also risks that do not become evident for some time.

The multi-faceted nature of risks and benefits

Both risks and benefits are multi-faceted. For example, there are many cases in which the same technology entails different risks and benefits after the international relations dimension has been factored in.

In domestic terms, nuclear technology is an energy technology and has the benefit of providing energy. On the other hand, it also entails safety risks. However, with the addition of the international relations dimension, the picture changes. With regard to decreasing the imports of oil, the principal energy source (most of which comes from the Middle East), nuclear power generation has the benefit of increasing energy security (although maintaining this option requires imports of uranium). On the other hand, possessing the technology for nuclear power generation (particularly technology for the nuclear fuel cycle) raises the risk of nuclear proliferation on the international level.

The same applies to space technology. Normally, the benefits of maintaining the capability to launch satellites go no further than satellite communications and satellite broadcasting. However, factoring in the international dimension, the technology yields security benefits, in the form of spy satellites. In addition, in a domestic context, dual-use technology is normally technology for public civilian benefit; however, it is recognized that there is a risk that, with the addition of the international dimension, its diversion to military use may contribute to the spread of weapons of mass destruction.

Moreover, the benefits of technology have changed due to society's changing objectives. For example, up until now, the provision of energy has been recognized as the sole benefit of nuclear power generation. However, as society has come to recognize global warming as a problem, the fact that it does not emit carbon dioxide—a substance that causes global warming—has come to be recognized as an additional benefit.

Conversely, when coal-fired power generation technology is discussed in the societal context of global warming, emphasis is placed on the risk entailed in its high levels of carbon dioxide emissions—a global-warming culprit. However, as factors such as rising oil prices increase concerns over energy security, the use of coal-fired power generation technology is seen to have energy security benefits, since the regions for production of the coal on which it relies are relatively spread out throughout the world.

Assessment of trade-offs

Thus, in the debate over the introduction of a new technology to society, diverse risks and benefits must be considered. Once these risks and benefits have been considered, there is then the problem of what kind of societal assessment should be carried out, based on these diverse risks and benefits. In the current context, there are various trade-offs that must be made when this societal assessment is performed (Graham and Weiner, 1998).

Risk trade-off refers to the fact that the efforts made to reduce specific risks conversely end up increasing other risks as a result. For example, if car bodies are made lighter in order to improve gas mileage, they become less collision-resistant and safety levels fall. In this case the global-warming and energy security risks are reduced, but the safety risk increases. In addition, certain products used as substitutes for CFCs (which destroy the ozone layer) have led to reduced destruction of the ozone layer, but have accelerated global warming. In this instance, the risk of the destruction of the ozone layer and the risk of global warming are traded off against one another. Further, methyl bromide, which is used as a fumigant to lower food-related risks, increases the risk of destruction of the ozone layer. In this instance, the food safety risk and the risk of destruction of the ozone layer are traded off against one another.

In regard to the AIDS cases caused by contaminated blood products, the division chief of the ministry in charge was found guilty in the criminal cases, since the switch from unheated blood products that allowed the possibility of AIDS infection to safer heated blood products was not made quickly. In the case of this trial too, there was an implicit trade-off assessment involved—albeit one that was tangential to the verdicts in the cases. Even before the heated blood products option had come into general use, the decision could have been made to revert to using cryo products—a possible treatment for AIDS and an option which had been available since before unheated blood products. The reason why this decision was not taken seems to have been that the risks entailed in using unheated blood products were judged to be low compared to the benefits—unheated blood products were highly effective and convenient for hemophiliacs. However, since some professional organizations were in fact championing a reversion to cryo products, logically a different decision could have been made (Hirono, 2005).

Assessing issues of values

When societal assessment of technology is carried out, it is necessary to consider issues that relate to values as well as conducting an assessment of the risks and benefits. To be more precise, the two should be carried out in concert with one another.

In regard to societal assessment of technology, it has been mentioned that a comprehensive assessment should be carried out after the risks and benefits have been widely clarified. However, when a comprehensive assessment is carried out, there is an important factor to be considered that will function as a "trump card"—whatever the other risks and benefits. This is the issue of values, as they relate to individual rights and human dignity. This frequently emerges as a key issue in the realms of life sciences and genetic engineering, which have advanced rapidly in recent years.

For example, there is now a problem in Europe with children themselves filing "wrongful life" lawsuits in complaint over their lives lived with disability or over their congenital disabilities (van Beers, 2007). These lawsuits are admissible in the Netherlands but have been banned in France. France claims that allowing these lawsuits would signify an admission that there are some lives that have no value, and that as this constitutes a eugenics-based view of human life, this violates the dignity of human life. On the other hand, the Netherlands adheres to the concept of the dignity of human life in the shape of empowerment that emphasizes giving people suitable powers as human beings, and believes instead that permitting lawsuits by children born with disabilities which could have been prevented comports with values of human dignity. This could be said to reflect differing conclusions over the importance to human dignity of values that stress the intrinsic sacred value of every living person or the need to protect the very integrity of the human body, and over whether to place an emphasis on values of self-determination or economic emancipation. This issue has now become a real problem, as technology for ante-natal diagnosis has advanced, making it technically possible to detect whether a person is disabled before birth.

Further, underpinning the current controls on animal experimentation being led by the UK is the utilitarian idea of the alleviation of suffering. This viewpoint requires that suffering be reduced as much as possible, but does not require that animal experimentation which provides experimental data essential to the development of science and technology be banned. On the other hand, if the view is based on the values of animal rights, as these were to be accorded the same importance as human rights, the conclusion could instead be drawn that animal experimentation cannot be permitted—no matter what the benefits.

Societal assessment of technology has also come to involve the issue of the image of society. With the growth of nano-technology, in recent years interest has risen in fields that integrate areas such as nano-technology, bio-technology, and information technology—that is, in converging technologies. In response to this, research is progressing in the USA and Europe on the implications for society of this technology. Research into the implications entails both finding out what the benefits for society would be and finding out what issues exist (for example, issues relating to the management of data collected using bio-sensors that employ nano-technology, and privacy issues). It could be said that there are certain different kinds of technology assessment, and in the course of this process, attempts have been made to differentiate between the respective aims of converging technologies in the USA and Europe. In the USA, the notion of “converging technologies for improving human performance” is asserted (Roco and Bainbridge, 2002), while in Europe the concept of “converging technologies for the knowledge society” is stressed (Nordmann, 2004). In other words, it could be said that in the USA this technology is being positioned as a means to improve facets such as human military capability and memory capacity, whereas in Europe the intention is to apply it for purposes that are more oriented towards society.

Promoting the generation of knowledge

The points that have been considered so far—how will society make use of science and technology, and what concerns must society take into account in its assessment of them—have been premised on the existence of science and technology. However, the existence of scientific knowledge and technology is not self-evident. For these to emerge, society must foster those groups of people to whom we refer as scientists and technologists, and must stimulate their research activities. What kind of knowledge generation, then, deserves to be stimulated?

In this context it is necessary to try and revisit the role of the legal concepts of “academic freedom” and “freedom of research” (Yamamoto, 2007). These concepts have often been considered as justification for the concepts of “science for the sake of science” and “research for the sake of research.” However, it seems that they could instead be retasked as the organizing principles for stimulating the generation of knowledge. In other words, simply carrying out research work under the directions of superiors in a hierarchical organization is insufficient to the generation of intellectual innovation. Certainly, implementation is a necessary component of research, and mechanisms to support this are essential; however, ideas—the essential component of research—are born of spontaneous investigative activity. According to this way of thinking, by enabling numerous trials and experiments in a bottom-up fashion, academic freedom and freedom of research have the resultant function of stimulating intellectual innovation, which contributes to society. The construction of a voluntary network that spans different disciplines is vital to this process. In addition, the significance of ensuring diversity in scholarship and research is that this can lead to just such intellectual innovation. Free and autonomous forms of organization made up of those involved (such as researchers) which stimulate spontaneous trials and communication are necessary to stimulate the generation of knowledge, and these are different from hierarchical organizations. In fact, promoting the generation of knowledge is essential even for risk assessment, which was mentioned earlier. A system of laws on experimentation that will allow various types of experiments is essential to stimulate the production of the information needed for risk assessment. If such a system of laws is absent and experiments cannot be carried out, there is no alternative but to rely on import of the knowledge and information needed for performing risk assessments. It has been pointed out that since safety regulations in Japan are often stringent, even the data needed to apply for approval and authorization under the safety regulations cannot be generated in Japan, and that instead foreign experimental data is used. This kind of situation does nothing to encourage the accumulation of the information and knowledge on which risk assessment is based.

On the other hand, it cannot be said that academic freedom and freedom of research command universal respect. For example, it is necessary to compare risk involved in the areas of safety and security. It is necessary to come to a decision on whether risks to safety ought to be considered and academic freedom and freedom of research curtailed, or whether shortsightedly placing the emphasis on safety and restricting research reduces the possibility of long-term innovation and increases society's vulnerability. Step-by-step clinical trials and medical technology for medical and pharmaceutical product trials are perfect examples of this. If Japan is to be independent in areas such as nuclear power technology, a legal system that enables experimentation is also required in the quest for independent technological innovation. A further issue is whether security risks should be emphasized and the publication of research (a key component of academic freedom and freedom of research) ought to be stopped when there are fears that research results might be applied by terrorists.

Institutional mechanisms for stimulating the generation of knowledge also include various other elements. Another bone of contention is whether intellectual property rights ought to be used to boost incentives for researchers. On one hand, if intellectual property rights are used as an economic incentive to spur researchers on to research success, the use of this mechanism will promote intellectual property rights. On the other hand, with people whose motivation to generate knowledge is not economic incentive, but rather the satisfaction of intellectual curiosity or the acclaim of fellow experts, the use of intellectual property rights in this fashion will not work. In addition, there is also the consideration that it will be difficult to put together knowledge by combining a variety of elements, if intellectual property rights are established separately for each component element. The basis of the traditional research community used to be the active use of the academic commons. Within research communities there has been an ethical emphasis on giving credit for an invention where it is due; however, the method that has come to be adopted involves sharing research results with the research community as soon as possible, and allowing them to be used for free, so as to stimulate the creation of further research results—and not to go to the lengths of obtaining intellectual property rights or to keep results secret. Whether to maintain the traditions of the academic commons or whether to make more use of intellectual property rights is a choice that will be crucial to the generation of knowledge.

In addition, other key issues will be how to design structures for the provision of research funding and how to plan the evaluation of research results. To make effective use of academic freedom and freedom of research, it will not be enough to simply preserve the autonomy of organizations—rather, it will be essential to allocate human resources and financial resources that will enable such activities. On the other hand, if resource allocation is carried out by the government, it is inevitable that there will be a certain level of evaluation, so as to maintain accountability; however, if short-term evaluation of individual projects is carried out, the goals of preserving diversity and maintaining the foundations for wide-ranging intellectual innovation will not be achieved.

Conclusion

This paper has outlined the substance and functions of science and technology governance. Two final points are worth identifying as fundamental science and technology governance issues.

First, it is noteworthy that different actors within society hold different viewpoints. It is important to understand the framework within which perceptions of the major issues are framed. There then has to be a from where the multiple viewpoints are shared and the interests are coordinated. Problems of science and technology must not be confined to the experts in the science and technology fields in question, but must be opened up to other interested parties as well. In the process, dialogue between experts and citizens is important; however, it is also important that there be dialogue between experts of different areas, and that language be devised that enables them to understand one another. There is a need for stakeholder analysis as a means to this end, and for leaders who will link together experts from various fields.

Second, it is not necessary for all the actors involved in the decision-making in governance to share a common vision. The notion of "sharing the same bed, but dreaming different dreams (Doushouimu)" is an important one. As has already been emphasized, the actors within society have different viewpoints and concerns. In this kind of situation, it is rare for visions of the various actors to be in accord. For example, some actors may be interested in nuclear power technology or bio-mass energy technology as measures to combat global warming, while others may be interested in these technologies as a means to achieve energy security.

In these instances, although the perspectives that inform the concerns of the actors differ, they will be able to form a united front in support of a particular technology choice.

Conversely, clarifying the various benefits and risks for the various actors through stakeholder analysis will not only provide the data for decision-making, but also look for the potential for coallition formation between the actors, based on the notion of "same bed, different dreams."

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