16 Risk Management

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Introduction

Risk management of social and economic activities is one of the most important issues that highly specialized contemporary society faces. Entities, including companies, are always vulnerable to social and economic risks stemming from future uncertainties. Risk is written in Chinese characters as 危機, which includes two contexts of danger 危険 and opportunity 危機. After understanding risk profiles from various perspectives, entities have thus far had to manage social and economic risks, categorized as those to be hedged or taken. These result in costs from potential dangers or returns from potential opportunities. However, there has been a gradual realization that it is difficult to find ways to solve social and economic risks in modern society by simply specializing or discretizing the categorized risks. For example, utility companies may consider the risk posed by nuclear power plants in terms of cash flows, while the potential for emergency situations may not necessarily be taken into account, in that the risk is not accepted by reinsurance. That is, existing risk categorization cannot solve issues related to risk. Additionally, it is myopically considered that the risk of climate change may be hedged using an emissions trading scheme, but in reality it is thought that the risk posed by climate change should voluntarily be seen as a technology innovation opportunity, resulting in actual emissions reduction in the mid- or long-term. It is safe to say that finding the solution to risk-related issues is significantly restricted by breaking the risks into parts. As the opposite vector to breaking down the risks, it has been gradually recognized that we need to solve the related issues by understanding segmented areas of expertise and connecting them flexibly in response.

This section attempts to discuss the problem of risk management through the new field of Human Survivability Studies (HSS) by going beyond the various areas of expertise. In this sense, the approach completely differs from that employed by existing disciplines. This may be seen as substantially disconcerting from the perspective of existing expertise. However, the new framework reorganizes different areas of expertise in order to solve risk-related problems and identify new values from the solutions. That is, we hope that our project can be considered as an experimental and completely different approach from existing expertise.

You may question the difference between existing Sustainability Studies and HSS. According to a dictionary, 'sustainability' derives from the notion of support from below in Latin, resulting in the context that existing prosperity maintains the world in the future. It follows that Sustainability Studies may involve the extension of existing expertise. In contrast, HSS is based on the word 'survivability', which stems from the Latin meaning 'a life beyond everything'. By transcending the world's current prosperity, it includes finding solutions to global complex issues and continuing to live in light of these solutions. The new approach of HSS entails a serious attitude toward life including the message: 'we must live here, continue to live and manage to live'. Thus, we can safely say that HSS can offer much needed expertise in order to achieve the ultimate goal of the continuance of human life through interdisciplinary engagement. How to transcend existing disparate areas of expertise and how to reorganize them are the keys to this approach and will enable us to solve the big issue of how to continue to exist. In this sense, HSS is transcending disciplinary boundaries by following the idea of 'in the same boat'.

The development of HSS is not aligned with existing sustainable development as outlined by the World Commission on Environment and Development (WCED) in the 1980s, but is instead connected to the new concept of 'survival development' in the sense of humanity's struggle to continue to live. In addition, the framework of existing fragmented areas of expertise implies the mechanization of human beings, in which human beings strive to achieve goals including solutions to global complex issues using microscopic views. However, it is often said that machines will not be able to take the place of human beings in the future. Human beings work to achieve goals including problem solving using intuitive and comprehensive recognition, which is quite difficult for robots. Like this, HSS, which reorganizes existing distinct areas of expertise to solve problems, can imply the mean reversion to the nature of human beings. In concrete terms, this new approach takes risk management issues on Earth as its starting point, and clarifies the essence of these problems. Then, by breaking existing frameworks of expertise into parts and reorganizing them according to risk management issues in a transdisciplinary way, studies using this approach attempt to demonstrate the possibility of finding solutions to them. HSS, which deals with solving practical issues and value creation, and existing areas of expertise differ in quality, but the former is not superior to the latter.

The next section examines three examples of risk management issues regarding business, natural resource development and science and technology ethics. The necessity of HSS is confirmed in the context of these three concrete practical issues after the limits to solving them using existing approaches are outlined.

Risk management in business activities

Risk management in business activities is a serious issue that concerns the viability of companies. A recent development in this field highlights the importance and urgency of risk management and calls for the assignment of a chief risk officer (CRO) to the management board to be responsible for dealing with risk management issues in practice. CROs work hard to keep companies going concerns by monitoring risks in complex and various business activities and conducting companywide risk management assessments. This subsection discusses three risk management issues: business decision-making that concerns the viability of companies, financial trading related to threats to the existence of financial institutions and project execution regarding company value in terms of cash generation from company projects.

Regarding risk management issues in business decision-making, we take the example of a stably growing power and gas utility company that enters into energy trading and engages in risk management by betting on energy trading with the aim of company survivability. A utility company that conducts its businesses with stable growth in the long run may try to avoid the market risk of energy trading, which is difficult to predict. This is due to the fact that a utility company can achieve high credit ratings based on its corporate management and can generate returns from the credit risk of energy trading. In concrete, a utility company may try to enter into risk neutral energy trading that matches short and long positions, resulting in a net profit from reliable price spreads based on the credit worthiness that avoids the market risk of energy trading. In order for a utility company to position energy trading as a new pillar of its businesses, the chief business executive who oversees the running of the company is not only familiar with the marketing of energy trading but also must be able to supervise the entire business comprehensively from above, including having a full understanding of risk assessment and management and the energy trading legal framework such as the Dodd-Frank law, and also have deep knowledge of energy trading.

Regarding marketing, the chief executive needs not only technical skills to enable deep insight into energy market observations and analyses, but also social and human science skills to allow them to negotiate with counter parties used for top-down sales. In addition, in order to determine the risk limits of energy trading and the direction of the energy trading business, the chief executive, in a broad sense, needs natural science skills to understand quantitative risk assessment and management. Furthermore, they are required to have legal skills to judge the validity of energy trading in the context of new legal frameworks that have been implemented in the wake of recent financial turmoil.

Another necessary trait is a philosophical framework to govern the direction of the company and relate to broader society when energy trading becomes a new pillar of the company. In this regard, when a top business executive works to solve business decision-making risk management issues and expands their new business for the survivability of their company, the more segmented and specialized the business components become, the more strongly the executive needs to possess the ability innate to HSS to understand and connect the fragmented areas of expertise in order to execute the business practically, i.e., make decisions. That is to say, existing specialized and segmented approaches in academia cannot solve the risk management issues in decision-making related to a company's survival and cannot create new value.

The risk of trading in financial sectors is represented as the extent to which future cash flows deviate from expectations, using the word 'finance'. In short, the deterministic future loss is not considered as a risk. Assuming that future uncertainties can be expressed quantitatively, the degree of variation from the expectation, e.g., the standard deviation for normal distribution, is taken as the risk. If the distribution is not symmetric like a normal distribution but skewed like a lognormal distribution, the risk should be adjusted depending on the shape of the distribution.

Categorization is the typical starting point in the process of managing risks arising from financial trading represented by the deviation from expectations. It is well known that two types of risk exist in financial trading. One is referred to as 'market risk', which represents changes to profit and loss caused by market volatility. The other is referred to as 'credit risk', representing existing position changes caused by counterparty default. Market risk is mainly measured by Value at Risk (VaR), which assumes that future asset price returns follow a normal distribution and represents profit and loss fluctuation of trading positions using a standard deviation of a normal distribution. Here, a confidence level such as 99% is taken depending on the tolerance of financial institutions to risk. Credit risk is measured by a restructuring cost due to counterparty default. In concrete, it is calculated according to the maximum exposure that can occur in the future. In addition to the two risks outlined above, operational risk (oprisk) is now highlighted as the third risk in financial trading. In financial trading, this is the other type of risk in which inappropriate or malfunctional internal processes, or human, systemic or exogenous events cause losses. Oprisk is quantified using the total sum of future losses driven by these factors. Thus, oprisks can be considered as those other than market and credit risks. However, there is a significant issue for the application of oprisk to financial trading businesses that differs from existing market and credit risks. That is, existing segmented areas of expertise such as the deeply specialized finance sector cannot provide answers to the quantification of oprisk, even when existing expertise attempts to qualify it. For example, input mistakes in financial trading, one of the significant oprisks, have to be mathematically modeled taking into account the structure of human behavior depending on human psychology. That is, in addition to statistics, different areas of expertise including psychology should be interconnected. More seriously, the management quality of oprisk by financial institutions has the potential to become a threat to the survival of financial institutions. While the concept of oprisk related to the continuation of financial institutions is understandable, the detailed quantification of such risk is still in progress. In order to solve risk management issues in financial trading, HSS, i.e., transdisciplinary fields, are required.

Finally, let's examine risk management in project execution directly related to the viability of a company. As the basic knowledge underpinning project management, the US Project Management Association proposed the Project Management Body of Knowledge. In this framework, a project management process includes risk management planning, risk identification, risk qualification and quantification, risk response planning and risk control.

Risk management planning defines the detailed implementation of project risk management. Risk identification highlights the determination of high impact risks and the detailed description of risk characterizations. In order to conduct further analyses, qualification analysis prioritizes risks by taking into account the occurrence of probabilities and their impacts. By doing this, we can focus on more prioritized risks and reduce future uncertainties. Quantitative risk analysis then calculates the impact of each risk on the project as a whole. By representing risk with a distribution, sensitivity analysis is conducted using, for example, tornado charts. In addition, risk response planning is carried out to identify the options and actions that can clarify the purpose of a project and alleviate potential threats. By doing this, we can handle each risk depending on priorities, budget planning, schedule and project management planning. Finally, risk control enables risk response planning to be reliably executed by observing time dependent risks and can comprehensively evaluate the efficiency of a project's risk process by tracking identified risks and monitoring residual ones. This risk control process can improve the efficiency of the risk approach, which continuously optimizes risk response planning through the project's life cycle.

Project management may specify the risk management process in detail and successfully conduct risk control. However, we have to remember that projects are conducted and lead by fallible human beings, not automatic machines. Therefore, even if risk management manuals are always revised properly, project managers have to navigate in the right direction in order to ensure the project will survive by taking into account the balance of the entire project, by identifying the essence of the problem from the perspective of risk and by recognizing and solving the problems by reorganizing different areas of expertise if unexpected events occur. That is to say, risk management in project execution cannot solve the issues by breaking things into component parts, i.e., using existing expertise in order to control risks practically. Risk management in project execution also needs the new concept or 'framework' of HSS, which reorganizes different areas of expertise and connects them in order to solve risk management issues related to human survivability, creating new value from risk management in project execution.

Risk and its management in resource development

Currently, we rely heavily on four kinds of primary energy sources – coal, oil, natural gas and nuclear power. These are all limited in amount, non-renewable and face depletion risk. On the other hand, the existence of large scale undiscovered oil fields is either confirmed or expected. For example, it is said that there are vast quantities of undiscovered resources under the Arctic Ocean. Although searching and mining the ocean floor is not easy, such difficulty can be overcome by innovation. In the US, moreover, it is reported that there is enough shale gas contained in the soil to supply that country for 300 years. In Japan's case, it has been reported that methane hydrate exists under its territorial waters. Research and experiments have been conducted in order to extract methane hydrate safely. Some people remain optimistic about energy problems because of these potentially available resources. Can we, however, realistically be optimistic? The main component of shale gas and methane hydrate is methane gas, which is the main component of natural gas, and thus they cannot be regarded as new primary energy sources. In other words, they belong to the abovementioned conventional primary energy sources. Humankind is set to use up four kinds of natural resources mentioned above within a few hundred years, which Earth has saved for 4.6 billion years since its birth. If we can discover a new unlimited energy source, there would be no problem with depleting these resources, but in reality, this is clearly not the case (see Chapter Thirteen for perspectives on new forms of energy). While leaving the discovery of a fifth energy source to the experts, I'd like to discuss the development of shale gas and methane hydrate, and examine the accompanying risks. Additionally, I attempt to explain the development of renewable energy (such as hydraulic, wind and geothermal power and so on) and the concomitant risks. Finally, I touch upon the importance of the approach enabled by HSS.

Shale gas is contained in fine-grained rock called shale. It was impossible to extract shale gas using conventional methods, until George Mitchell developed new techniques called horizontal drilling and hydraulic fracturing, which can be used to make cracks in shale rock and efficiently extract the gas within. Industrial production and usage of shale gas has already begun in the US. Methane gas itself, however, remains problematic, because its greenhouse effect is twenty times as strong as that of CO_2. Shale gas is quite an efficient fuel, but at the same time, it is concerning that leaked residual methane gas, if left unburned, may cause detrimental effects on climate change. Moreover, there are concerns regarding the possibility of environmental pollution caused by chemicals used in the process of hydraulic fracturing, and also the potential induction of earthquakes in relation to the injection of copious amounts of water underground. Risk and its management around the development of shale gas must be addressed through not only the field of engineering, but also via a multifaceted approach including measures to prevent climate change and environmental disruption as well as legislative measures.

Methane hydrate is a dodecahedron crystal with pentagonal faces, each of twenty apexes of which has an oxygen atom originating from a water molecule. At the center of the structure sits a methane molecule. Methane hydrate exists in a solid-state in the water below 400 meters below sea level. Once extracted from the sea, however, it becomes sherbet-like. If ignited, it burns with a blue flame. It is estimated that there is six trillion cubic meters of methane hydrate deposits in the oceans around Japan, and 250 trillion cubic meters of it in the world. Although methane hydrate seems a potential alternative energy source for the future, there are concerns similar to those regarding shale gas development: the potential induction of earthquakes and detrimental effects on the environment. In addition, the actual utility of methane hydrate depends on whether we can come up with an innovative and economically plausible technique. As in the case of shale gas, we need the perspective of HSS in order to resolve the risk and management problems around methane hydrate.

Next, I'd like to touch upon the development of natural energy and surrounding risks. Even though natural energy resources such as wind, geothermal and solar are deemed 'clean', they do not come problem free. In terms of wind power generation, Japan has a prima facie advantage, as it is surrounded by sea; Japan's territorial waters, including its exclusive economic zone, covers 4.48 million m^2, which is the sixth largest in the world. Although some areas are not suitable for offshore wind power generation, it is estimated that such method can generate as much as 600,000 MW (equivalent to 230 nuclear power plants), combining fixed bed type and floating type turbines, even if we narrow down the areas of operation according to certain conditions, such as 7.5 m in annual average wind velocity, or a water depth of 200 m or shallower. While research and experiments are ongoing, there are problems in terms of noise pollution from wind turbines and fishing rights. In contrast, European countries with shallow surrounding waters, such as the UK, have already begun operations of fixed bed type offshore wind power generation. When it comes to geothermal power generation, Japan has land use restrictions and faces legal obstacles. For example, power plants cannot be built in national parks or semi-national parks.

Solar panels haven't changed much in terms of size over the past twenty years, as the light energy conversion efficiency has not improved. Therefore, we still need a vast amount of land to house solar panels. Indeed, in order to produce the same amount of electric power generated by a natural gas power plant, we need 3,000 times as much land to accommodate the solar panels. If we try to generate enough electricity for the whole country solely using solar panels, we would need 25,000 m^2 of land, which is equivalent to Shikoku Island and Ibaraki Prefecture combined. Construction cost is also an issue, as building a panel that can generate one kW of electricity costs 500,000 yen.

Finally, I'd like to touch upon problems with biofuels. One example of biofuel is ethanol produced from corn. Corn contains a large amount of starch. Starch can be decomposed into glucose using enzymes, and glucose can be made into ethanol when fermented. Using this method, we can obtain ethanol with a concentration of up to 20%. To increase the concentration, ethanol has to be separated from water. This necessitates a significant amount of energy. Since large amounts of fuels are indispensable in the production, transportation and fermentation of corn in the first place, it is a concern that energy consumed in the process of making biofuels might exceed the amount of energy gained. Moreover, food prices soar when food resources

– corn – are converted into fuel. New technology that can convert inedible cellulose into ethanol is desirable.

As explained above, in order to manage the risks regarding natural energy sources, such as wind, solar and biofuels, it is necessary to have a comprehensive approach involving multi-dimensional aspects, including not only engineering, but also law, the economy and so on. Once again the need for HSS, which maintains a transdisciplinary approach, becomes evident.

Risk management and science and engineering ethics

Aside from associations of government-recognized occupations, such as medical doctors and lawyers, there has been no code of ethics in Japan, because it was presupposed that Japanese people would voluntarily stick to the general framework of ethical rules. Concepts like science or engineering ethics were not considered until recently. In other words, we may have been fortunate in not having to be conscious of ethics. In the US, textbooks about engineering ethics have been available for decades, whereas there were none until recently in Japan. It is not surprising, therefore, that engineering students at universities did not receive education in ethics. This is because Japanese people's strong sense of belonging to corporations places more obligation on employers than the public.

However, since the Tokaimura nuclear accident – caused by negligence regarding the predetermined procedure to melt uranium compound – occurred in 1999, there has been a series of incidents in which the ethics of engineers or companies have been questioned. These include:

1. The Snow Brand Milk Products Co., Ltd. food poisoning accident, caused by a lack of basic sanitation management of food products, resulting in the poisoning of more than 10,000 people.
2. The attempt to conceal issues at several nuclear power plants, where no record was made that these problems existed and that repairs were needed, and on the day these issues were discovered the facts were repeatedly manipulated
3. The West Japan Railway Company Fukuchiyama-Line derailment accident, which occurred on a curve due to excessive speed.

Because of these incidents, individual engineers are now required to be fully aware of the ethical aspects to their work. How engineers should deal with work-related ethical problems is a matter for discussion. It is certain that all the engineers involved had to face considerable difficulties in the wake of the 2011 accident at the Fukushima-Daiichi nuclear power plant, caused by the Great East Japan Earthquake. At the same time, a single engineer cannot be responsible for answering questions like ‘whether or not nuclear power generation should be suspended’. Rather, such issues must be discussed by various stakeholders including engineers, and encompass diverse opinions from multiple areas, before reaching a conclusion. Many universities have now initiated ethics education. I hope it will become a compulsory subject in the near future.

Recently, frequent wrongdoings in the course of scientific research have come to light. These incidents disturb the mutual trust that is the major premise of any scientific research. Case studies can be categorized into three types: (1) fabrication, or creating fake data; (2) falsification, or intentionally modifying/misrepresenting relevant data; and (3) plagiarism, or stealing other scientists’ ideas. The fabrication and falsification of papers on embryonic stem cells, cold nuclear fusion and organic high temperature superconductors are still fresh in our memories. In addition, many cases of data modification or fabrication through the abuse of image processing technology have been reported. Such situation was made manifest against a background of tremendous progress in the image processing capability of computers. We live in an era when a person’s photo can be altered to appear like that of a complete stranger. When writing a paper, any researcher would want to provide readers with pictures as clear and easy to understand as possible. If one picture is unclear, the whole experiment should be repeated and a photo should be retaken. Yet in some cases, researchers instead amended the original pictures. It may have begun with a casual thought that it would be allowable to adjust contrast, but such adjustments could escalate infinitely, leading eventually to complete fabrication. Those who do not possess self-restraint, and thus cannot avoid this kind of temptation, do not qualify as researchers. Although the likelihood of problems occurring depends on the nature of individual study areas, experiments that nobody can reproduce are either fabrications or falsifications. Depending on the area of research, how easily a third-party can conduct a replication varies significantly. Researchers in areas where anybody in the world could conduct a replication within a few days after a paper is published cannot rely on fabrication or falsification. In contrast, animal tests for drug development are far more time consuming and troublesome to replicate, as one has to start by securing animals for experiments. Therefore, it would be impossible to conclude whether or not any false element was involved in the original tests. Wrongful acts tend to occur in this kind of area.

Dishonesty in clinical tests is sometimes reported by the mass media. As mentioned in Chapter Twelve, drug development takes time and the costs are considerable. Even if the basic research (drug discovery and exploratory research) is done and non-clinical trials are successful, the developer cannot recover their expenses unless the drug passes the clinical trials to be sold in the market. For pharmaceutical companies, the moment that determines whether a drug, which required so much time and money to develop, can be sold or not is critical. They can expect to achieve sales reaching tens of billions of yen per year if the drug passes the clinical trials. This motivation accounts for the misdeeds. For whatever reason, modifying or fabricating experimental data is not permissible. It could be a tragedy for a patient if a drug produced based on false data was not only ineffective, but also entailed hidden harmful side effects. Such cheating would be tantamount to a crime, rather than an ethical problem. Researchers and managers engaged in drug development are required to have a strict code of ethics. Needless to say, the same applies to the medical professionals who execute clinical trials. In terms of risk management regarding drug development, we need to connect multiple disciplines, such as public administration and the study of ethics, let alone pharmaceutical science, so that we can reach optimal solutions.

In the context of severe competition in scientific research, there is psychological pressure on researchers to produce positive results before others, and such pressure leads to misdeeds. Nevertheless, fabrication and falsification render precious time and money for scientific research futile, and eventually disrupt scientific progress. They may even cause societal distrust in scientists. In order for science to regain trust from society, each scientist has to become conscious of their responsibility, and relevant entities, such as universities and companies, need to seriously design and execute preventive measures against wrongful research.

Researchers' lack of ethics caused by the drastic slide towards fragmentation in disciplines such as science and engineering forms the backdrop of the current situation, in which risk management regarding scientific/engineering ethics is required. When we try to solve problems related to risk management in this area, the transdisciplinary approach of HSS will become increasingly indispensable.