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The Catastrophes and the Combined Failure of Institutions, Part I: A Comparison of Fukushima and Minamata*

By

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Abstract

This paper will attempt to understand how institutional failure should be detected and remedied quickly to limit the extent of damage caused by catastrophes, focusing on two significant cases in Japan: Fukushima and Minamata. Such a damage can be a manifestation of the combined failure. Also, as the causes of the cases relate to social technologies as well as physical technologies, it is necessary to adopt a trans-disciplinary approach which makes it possible to mobilize different capabilities of social and natural scientists, practitioners, and policymakers.

Keywords

Catastrophe, Fukushima, Minamata, Trans-disciplinary Approach, Combined Failure of Institutions, Business Ecosystem Governance, Corporate and Global Sustainability

Introduction

This paper aims to understand the nuclear disaster caused by Tokyo Electric Power Company (hereafter, TEPCO) in 2011 as well as the heavy pollution triggered by the Chisso Corporation (hereafter, Chisso) in the 1950s. We assume that the main cause of these catastrophes could be the combined failure of institutions such as the government, the market, and the firm and seek for a trans-disciplinary approach to the failure, which cannot be controlled by humans even if we rely on gee-whiz research outcomes in sciences and state-of-art technologies. The two cases of Japanese companies, which deeply relate to such

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multiple institutional failures, necessitate us to go beyond the traditional concept of corporate governance, namely institutional design of a corporation to improve its shareholders' value, and then to construct a new concept of governance at the level higher than the corporate level.

On the other hand, trans-disciplinary approach, unlike the interdisciplinary one, facilitates to mobilize and rearrange a wider set of knowledge across the science in a multi-lateral, rather than bilateral, way. This could be vindicated by the fact that the catastrophes relate to social factors such as inappropriate laws and regulations, improper organizational decision making, and institutional inertia, as well as natural factors such as massive earthquake and tsunami, toxic chemicals, and radioactive materials. As a result, we have to build a bridge over natural and social sciences which enables scholars with different backgrounds, including economists, engineers, chemists, seismologists, jurists, management scholars, radiation scientists, and so on, to deal with the same issue from different angles if we are to tackle issues like pollution and nuclear accident, which in fact threaten our lives and Earth considerably.

In this respect, it seems reasonable that the debates on corporate governance must be reformulated in the way that they could deal with the problem of how we could improve global, rather than corporate, sustainability to protect our future on Earth. However, economists who have expertise in law and economics and corporate finance tend to engage in the debates by making use of highly sophisticated mathematical models based on contract theory to advocate shareholder value maximization, leading to corporate sustainability (e.g. Shleifer and Vishny 1997; Tirole 2001, 2005). At present, they seem to be well-satisfied with the mathematical theory of the contractual governance of the firm in terms of optimal monitoring and incentive systems under the situation of information asymmetry between managers and shareholders (Taniguchi 2011). Of course, it would be necessary for us to broaden our perspectives to take account of global sustainability, which cannot fit in the goal of profit maximization that corporations must seek for their shareholders.

But ultimately, global sustainability would deteriorate corporate sustainability. It would be easy for us to imagine that humans cannot live a life of reassurance and health in the sphere of habitation with contaminated water and food, polluted air, perennial disease and infection, high frequency of natural disasters such as earthquakes and hurricanes, a frequent occurrence of terrorist incidents and regional conflicts, significant loss of land through rising sea levels, severe deterioration of environment, and so on, which erode the sustainability of Earth at a steady rate. Inevitably, such factors prevent corporations from running their businesses smoothly and thus this might lead to loss of corporate sustainability in the long run.

In general, climate change is regarded as a paramount and even urgent issue among the growing challenges of global sustainability. For example, in 2006 a team of economists at HM Treasury led by Lord Nicholas Stern published the so-called Stern Review which served as the foundation of the Climate Change Act 2008, prescribing that the UK economy should reduce greenhouse gas emissions by 80% of 1990 levels by 2050. The preparation and publication of the Stern Review was actually initiated by Gordon Brown, the Chancellor of the Exchequer, and has inspired international discussions on climate change to facilitate action on decarbonization. Thus in the case of the UK, the initiatives to deal with the issues on global sustainability, ranging from global warming to renewable transport fuel obligations, were offered by the government rather than the corporation.

However, it seems unlikely that corporations are willing to engage in actions which are

consistent with global sustainability if such actions impose prohibitive costs on them which would undermine their profitability. In addition, government has strong incentives to improve its sustainability, namely to create self-serving organizations with unimpeded growth, by expanding its interests in the context of interactions with the private sector. For example, the case of the Fukushima nuclear crisis illustrates this. In particular, the METI (Ministry of Economy, Trade and Industry), a part of the government which is in charge of *both* nuclear development *and* nuclear governance, has colluded with electricity companies, including TEPCO, with a view to be provided job opportunities for bureaucrats after retirement by the companies. On the other hand, the companies expect the ministry to formulate laws and regulations in a preferable way to them in that the institutions facilitate particularly the development of nuclear power generation, which is such lucrative a business on which their business models rely heavily in order to increase corporate value and thus corporate sustainability. In the same way, the collusion between the government and corporations has also been responsible for the heavy mercury pollution of the Minamata bay in the 1950s and 1960s, which caused the Minamata disease. In this particular case, the MITI (Ministry of International Trade and Industry)¹ and Chisso, the firm directly responsible for the disaster, funded research into alternative causes of the disease, other than the factory waste, in order to find a social solution and calm down the mounting anger of the public opinion. It seems that after 50 years the lesson has not been learned and the tendency of corporations, together with government bodies, to put profits ahead of health, safety, and environment (HSE) is still persistent.

Therefore, the government should be taken as an endogenous player with its own incentives and interests rather than a neutral, omnipotent enforcer of institutions exogenously attached to the economy (Aoki *et al.* 1997). Thus, government might be involved in the activities to increase corporate sustainability if it is likely that this enhances the sustainability of government as well. Subsequent emergence of the collusion between government and corporations should be governed to align corporate sustainability with global sustainability by facilitating learning among different organizations synchronically and diachronically, or locally and globally. Such capability transmission function is required to tackle issues like Fukushima and Minamata in as swift and appropriate a way as possible.

The paper is organized as follows. We examine why a trans-disciplinary approach is required for understanding the issues on governance. After sketching out the cases of Fukushima and Minamata, we compare one with the other to derive some lessons for the future development of governance. Concluding remarks follow.

Why a Trans-Disciplinary Approach?

Rethinking the Firm and the Corporation

We are living in the real world occupied with a variety of corporations, ranging from business corporations to democratic states. However, it seems odd that economics has not dealt with the conceptualization of the corporation for decades. In particular, economists prefer to tackle the issues of how firms are governed and organized, following the tradition of new institutional economics (Coase 1937; North 1990; Williamson 1975, 1985, 1996). More recently, the discussions on corporate governance have been actively developed among

¹ MITI was reorganized as METI in 2001.

economists who have expertise in law and economics and corporate finance. In essence, most of them have contributed to the debates by making use of mathematical models, and focused exclusively on the nature of governance to align the interests of managers with those of shareholders within a corporation.

Since a path-breaking empirical study on business corporations by Berle and Means (1932) was out, it can be said that separation of ownership and control has been part and parcel of the corporate governance literature. In particular, mainstream economists have looked to the assumptions of information asymmetries and incentive misalignments between shareholders and managers in constructing theories of the firm, which have recently become known as organizational economics (e.g. Alchian and Demsetz 1972; Williamson 1975, 1985, 1996; Jensen and Meckling 1976; Milgrom and Roberts 1992; Hart 1995; Baker *et al.* 2002; Gibbons 2005). Their main focus is on the information and incentive problems that result from the conflicts of interests between shareholders and managers when they write and enforce contracts. As Posner (2010) succinctly puts it, organizational economics puts emphasis on the relationship between organizational structure and compensation systems as well as innovation, information systems, agency costs, and economic efficiency. In organizational economics, the challenges to modern firms are to coordinate the expectations and activities of their members and to motivate them in order to economize agency costs due to information asymmetries and distorted incentives.

In fact, these are sources of agency costs and imply the significant losses of shareholder value. In the agency relationship, getting the governance system right for controlling managers' opportunistic actions is expected to implement desirable outcomes for shareholders. Thus, to design enforceable contracts that could incentivize managers whilst also maximizing shareholder value would be a challenge for mainstream organizational economics.

When they deal with corporate governance, mainstream organizational economists insist that governance is all about how to design the contracts in terms of optimal monitoring and incentive compatibility. However, the problem is that the conceptualization of corporation has been tidied up by the time they finish the argument of corporate governance. And even the nature of the firm has been inappropriately attributed to a mere contractual issue. For them, what is or is not a firm is just trivial (Cheung 1983).

Moreover, this contractual view of the firm would insist that only the contract law should be essential, whereas neither the corporate law nor the corporate form should be important. In other words, the view takes the corporation as a veil. It tells us that the corporation is a legal fiction that simplifies the complicated contractual relationships among stakeholders, and that the firm is a market, and far removed from the concept of the real entity.

In particular, jurists and legal scholars have been debating for years as to what constitutes the nature of the corporation. This is known as the corporate personality controversy. According to Iwai (2003), two competing theories, corporate nominalism and corporate realism, have emerged in the literature. The former takes corporations as names, whereas the latter treats them as purposeful beings clearly separate from their members and confer rights and duties on them. As an examination of the controversy goes beyond the scope of this paper, we should constrain ourselves here to noting that the contractual view of the firm corresponds to corporate nominalism in jurisprudence and argues that neither the firm nor the corporation matter.²

²Furthermore, it can be said that this view admits positive transaction costs to expand its territories of market analysis into the firm.

Of course, both the firm and the corporation do matter. First, we have to ponder the nature of the firm. Coase (1937) argues that the *raison d'être* of the firm as an authority figure, where resource allocation is achieved through management, can be explained in terms of comparative efficiency in economizing the costs of using a resource allocation system. Within a firm, market transactions are eliminated and substituted by the management as a coordinator. The contracts that the members with bounded rationality can write are incomplete in that the contracts cannot reflect *ex ante* everything that will happen in the implementation process *ex post*, and thus imply unforeseen contingencies. Thus the Coasean firm requires the working of institutional complexities such as ownership (Grossman and Hart 1986; Hart and Moore 1990; Hart 1995) and corporate culture (Kreps 1990; Hodgson 1996, 1998) to adapt to unforeseen contingencies.

However, Coase failed to explain the historical continuity of the firm. Since Penrose (1959), scholars in the camp known as the resource-based view (e.g. Wernerfelt 1984; Barney 1991, 2002) or the capabilities view (e.g. Nelson and Winter 1982; Langlois 1995; Langlois and Robertson 1995) have paid much attention to the issue. In general, their views of the firm are dynamic and historical. As for the dynamics of the firm, Langlois and Robertson (1995) argue that the comparative advantage of the firm over the market is to reconfigure and create the necessary capabilities when synchronic changes of several stages of production are required and when these capabilities cannot be acquired in the market at low cost. This idea has been expanded into the function of the meta capabilities, more correctly dynamic capabilities, necessary for redeploying and reconfiguring of those capabilities to create change (e.g. Teece and Pisano 1994; Teece *et al.* 1997; Helfat *et al.* 2007; Teece 2009; Pitelis and Teece 2010; Helfat and Winter 2012).

In summary, Coase formulated a static framework for comparing efficiency in transaction costs economizing between the market and the firm. On the other hand, Penrose and her successors presented the firm-as-a-collection-of-capabilities view with a more dynamic flavor than the Coasean firm. Nevertheless, both of them still lack the conceptualization of the corporation.

Second, we need to conceptualize the corporation in a realistic way. This implies that it would be necessary for us to build theories of the corporation as a self-governance device. Modern corporations have a specific set of institutions which constrains and enables the collective action and associative cognition of the organizational members. In this respect, Aoki (2010) regards corporations as “*voluntary, permanent associations of natural persons engaged in some purposeful associative activities, having unique identity, and embodied in rule-based, self-governing organizations*” (p. 4: emphasis in original). If cognitions are organized within the organization in a systematic way, then coherent decisions may be made for collective action. One of the most important *raisons d'être* of the corporation is to achieve associative cognition.³

On the other hand, Greif (2006) views corporations as “intentionally created, voluntary, interest-based, and *self-governed* permanent associations” (p. 308), including guilds, universities, communes, and city-states in medieval Europe as well as professional associations, business corporations, and consumer groups in modern societies. These were purposefully created in that intentional and coordinated efforts by many individuals were needed.

The law constrains possible choices of corporations by specifying prerequisites that

³By intentional design as well as through conventions and routines evolving during overlapping generations of its members, cognitions are systematically distributed among the members. For more on this, see Aoki (2010, pp. 22–23).

should be fulfilled under the rule of general incorporation. Additionally, it functions as a cognitive resource when the parties attempt to achieve contractual cooperation through a process of social learning in the corporation (Carvalho and Deakin 2008). Thus, corporate institutions such as company law and the governance system are both constraining and enabling people's cognition and actions (Aoki 2001).

Moreover, the law is required for firms to have corporateness (e.g., Hansmann and Kraakman 2000; Stout 2005; Deakin 2011). The succession of capabilities from generation to generation could merely be of an ephemeral nature if a firm were not equipped with this corporateness. Corporateness includes the transferability of shares through markets, limited liability throughout shareholders, running the business through organs such as the CEO, board of directors, and shareholders meetings. In modern economies, the development of the law and market supporting institutions enables organizations to avail themselves of corporateness and metamorphose into corporations. Deakin (2011) argues that the firm as an economic organization cannot enjoy the benefits of permanence and autonomy for assets inherent to the corporation without the law. Thus it can be said that an attempt to deprive the notion of the firm of legal meaning would be inappropriate and even dangerous (Taniguchi 2011).

In the following, we will present a new concept of governance which is more likely to understand the emergent cases of catastrophe such as Fukushima and Minamata that had a pernicious effect on the sustainability of the nation and Earth.

Business Ecosystem Governance and Global Sustainability

As noted above, the issues on corporate governance have been reduced to how to design the contracts in terms of optimal monitoring and incentive compatibility. As Williamson (2010) puts it, "governance is the means by which to infuse *order*, thereby to mitigate *conflict* and realize *mutual gain*" (p. 674: emphasis in original). He regards governance as an institutional device to solve the issues arising from asymmetric information and misaligned incentives. In this regard, Hansmann and Kraakman (2001) confidently insist that continuing convergence toward a shareholder-oriented model is most likely and thus corporate law should strive to increase long-term shareholders' value.

Yet since the global economy has suffered a deathblow from the 2008 financial crisis, the shareholder-oriented view has been under severe scrutiny. It is obviously insufficient to resurrect the stakeholder-oriented view if we seek to gain a full understanding of what corporations should do for improving global sustainability. In the stakeholder-oriented view, balance of power among stakeholders has been taken up in the context of value capture within a corporation (Aoki 1984; Blair 1995). Beyond this, we must take account of the compatibility of corporate sustainability with global sustainability and the possible value creation by greener businesses.

Historically, society and industry in particular, have achieved development with almost complete disregard to environmental issues. Many environmental organizations argue that the unsustainable use of natural resources is considered to be a direct consequence of a profit driven, competitive economy. Lancaster (2010) argues that the environmental issues we have now and predict for the future are partly due to societies' collective pursuit of myopic economic growth. However, as the impact of industrial activities on Earth and our lives becomes more and more detrimental, it seems clear that this view of development is no longer appropriate and a new framework in which corporations operate is necessary.

In the early 1990s, the US Environmental Protection Agency (EPA) coined the phrase

'Green Chemistry', which refers to as "the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances" (<http://www.epa.gov/greenchemistry/>). The fundamental challenge for the chemical industry in particular, and for the industry in general, is to continue to provide the benefits to society without damaging the environment in which we live and at an acceptable cost. This implies an intimate relationship between corporate and global sustainability, i.e. a proper equilibrium between the two. If we continue to pursue corporate sustainability regardless of global sustainability, the human race is likely to face disastrous consequences.

In fact, Rees (2003) argues that the odds are fifty-fifty that humans will survive to the end of the 21st century if we even luckily do not face disastrous fiascos. But unfortunately, disasters could occur ubiquitously. He goes on to put it.

Disastrous accidents (for instance, the unintended creation or release of a noxious fast-spreading pathogen, or a devastating software error) are possible even in *well-regulated institutions*. As the threats become graver, and the possible perpetrators more numerous, disruption may become so pervasive that society corrodes and regresses.

Rees (2003, p. 4: emphasis added)

Rather, as we will see later, humans are at risk of exposure to disasters in *poorly-regulated institutions*. At least, the cases of Fukushima and Minamata illustrate this. Rees' concerns about the sustainability of human society would serve a trigger for us to raise the odds of survival as much as possible. This necessitates institutions, ranging from markets to firms to governments, to be designed and governed in a more sustainable way so as to minimize the possibility of disaster.

But in fact, we have observed that the number of disasters from natural sources (e.g. earthquake, hurricane, and tsunami), from corporate and industrial sources (e.g. nuclear accident, oil spill, and explosion accident at chemical plants), and from deliberate sources (e.g. terrorist attack) have increased dramatically. In 2012 Swiss Reinsurance Company (Swiss Re) published the Sigma report (Swiss Re 2012) that included the evidence of natural and man-made disasters across the world. The report shows that 325 catastrophes occurred in 2011, 175 of which were natural disasters and 150 of which were man-made disasters, that total economic losses due to such disasters amounted to 370 billion dollars, and that the total number of victims were 34,729 (Swiss Re 2012).⁴

Historically, the world's worst man-made disaster in terms of victims is the Bhopal gas tragedy occurred on 2 December, 1984 at the Union Carbide India Limited pesticide plant. The Sigma report estimates that the number of dead and missing in this disaster amounts to some 6,000. But this might be an underestimation if we compare it with the estimates of the BBC: official figures on initial deaths are nearly 3,000 and subsequent deaths are some 15,000, while unofficial figures on initial deaths are more than 7,000 and subsequent deaths are more than 15,000 (BBC 2004). Although the Indian Supreme Court ruled that a safe water system should be installed to the affected communities, the water supply is largely irregular and local residents are still forced to rely on the water contaminated mainly by hexachlorobenzene, an animal and probably human carcinogen (Ansell and Tinsley 2011).

In this way, a corporation could destroy local communities and be guilty of manslaughter-

⁴2011 ranks as the 16th highest year in terms of victims since 1970, when the company started collecting data of the catastrophes occurred across the world and the Bangladesh storm and the Peru earthquake befell (Swiss Re 2012, p. 6).

ter by causing fatal disaster, involving release of hazardous materials which create health menace hopelessly. If we face either the case that a disaster occurs at the capital of a nation or the one that several disasters break out at some places in a nation simultaneously, this would considerably paralyze the functions of the nation or even worse, have life-threatening impact on countless numbers of citizens and thus deteriorate the sustainability of the nation thoroughly. If corporations lack an adequate set of governance mechanisms which leads them to run their businesses in a safe and sustainable way, this scary scenario becomes reality. It seems likely that the scenario would be detrimental to the sustainability of the corporation, the nation, and even Earth in the long run.

How can we prevent the scenario from happening in the real world? Although history shows us that corporations tend to repeat the same mistake, could they have avoided the scenario if they had learnt from the past, directly or vicariously? At least, it would be possible for us to argue that good governance can minimize the potential for disaster to make a corporation align its sustainability with global sustainability and demand it to pay much attention to the adequacy of the social and physical technologies and the possible natural disaster, which could be taken as random event or context. This idea reflects the theory of possible worlds (Lewis 1986), insisting that the actual world could be regarded as one of the many possible worlds which could be expanded by imagination. Taniguchi (2012) argues that the catastrophe like Fukushima can be taken as a possible world, or simply a world, consisting of the factors such as the social technologies (e.g. laws and regulations, organizational forms, and governance), the physical technologies (e.g. chemical engineering, preventive care, and antiseismic building), and the context (e.g. earthquake, typhoon, and tsunami).

As a disaster occurs in time, the causes of the catastrophe should be explained in terms of process rather than outcome if we are to understand them properly. This implies that history matters. For simplicity, we can decompose the process into the *ex-ante* stage, the *interim* stage, and the *ex-post* stage along the passage of time. As historical explanation of what a disaster unfolds requires an examination of how a world develops at each stage, we need to focus on the relevant factors of the world.

However, it seems likely that the *ex-ante* stage is not often explained sufficiently in understanding how the world happened. In this light, unlike most do, we believe that the causes of the Fukushima nuclear crisis cannot be reducible exclusively to either massive tsunami as TEPCO insisted or the moral hazard actions of top management of the company as some scholars (e.g. Yamaguchi 2011; Takemori 2011) held. And as the choice of the physical technologies is institutional in that it reflects organizational decision making, which is the outcome of interactions among people in the corporation, the combined failure of institutions, or more simply multiple institutional failures, at the *ex-ante* stage can be the important *explicans* of the crisis as *explicandum*.

Here, we would like to return to the issue of governance. Governance should be about global sustainability rather than corporate sustainability. Originally, the report published by UN WCED (World Commission on Environment and Development) in 1987 presented the definition of sustainability in the context of sustainable development, meaning development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (<http://www.un.org/documents/ga/res/42/ares42-187.htm>).

However, Pitelis (2012) redefines sustainability in terms of value creation at the firm, national, and global levels. In order to achieve sustainability at different levels, addressing the hierarchy of agencies, which consists of the agency between management of the corporation and its stakeholders, the one between the corporation and the government, and

the one between the government and the global community, is a major prerequisite for improving global sustainability. He raises the issue of institutional design that leads to an alignment of the object at each level as a whole as well as compatibility of value capture at lower level with value creation at higher level.

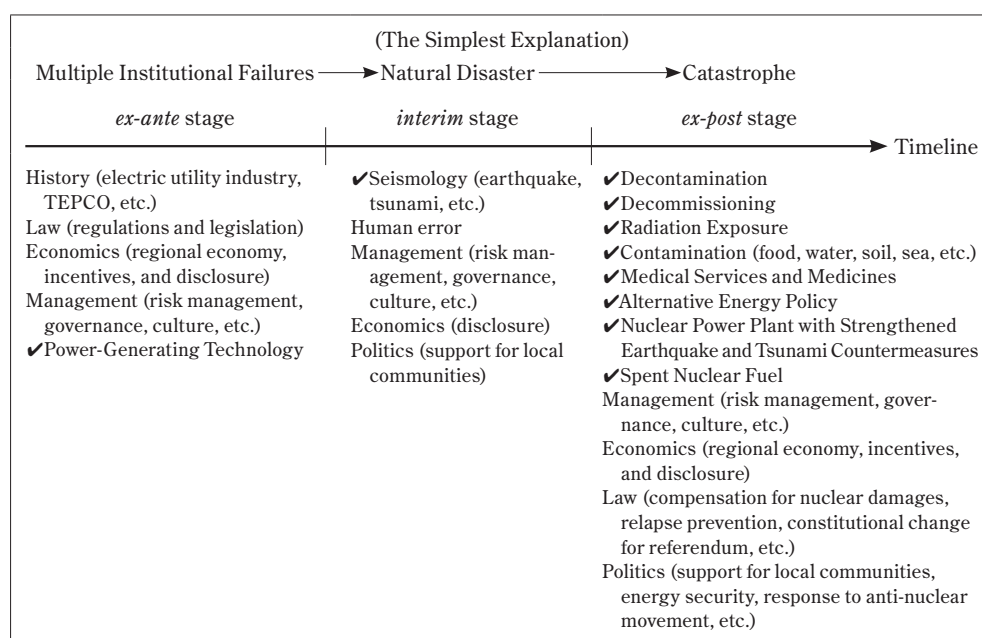
Taking account of the hierarchy of sustainability, Taniguchi (2012) presents the concept of business ecosystem governance to understand the Fukushima nuclear crisis to which traditional concepts such as stakeholder and corporate governance are not applicable because it involves the business ecosystem consisting of the society and the nuclear village.⁵ The nuclear village affects nuclear development, while the society is affected by nuclear development. The nuclear village can be regarded as a meta-organization, which represents a network of organizations and individuals not bound by authority but by a system-level goal (Gulati *et al.* 2012), i.e. nuclear development. It is the collusion between the Japanese government, electricity companies, the industrial associations (e.g. Japan Federation of Electricity Companies), and so on. If we take the process of the crisis seriously, it would be more correct to say that the crisis was caused by the nuclear village rather than TEPCO solely.

Thus we pay heed to the governance of business ecosystem consisting of the nuclear village and the society, rather than the governance of TEPCO. In the era of globalization, business ecosystem governance is expected to facilitate the formulation of consensus, capabilities transmission, problem-solving, and disciplinary actions across the national border among a set of individuals, organizations, and meta-organizations to improve global sustainability. But at present, it is still an ideal concept without practice. This is partly why nuclear accident was turned into nuclear crisis at Fukushima unfortunately. And this paper puts much emphasis on capabilities transmission because we are interested in deriving lessons from the case of Minamata which could be used effectively to mitigate possible environmental and human damages from the Fukushima nuclear crisis.

Moreover, both cases necessitate us to identify and examine a series of issues along the timeline, ranging from production technology to human errors to compensation for damages, which represent just a fraction of the tasks that we should deal with toward problem-solving. Among others, public disclosure of the right information is certainly an important task for organizations and meta-organizations in that they have to tackle it at every stage to fill in the gaps between them (information-haves) and have-nots. This still stays within the familiar story of corporate governance on which that economists and management scholars have doted. But our claim is that disclosure is not enough to understand the causes of the catastrophes and solve the emergent and secondary issues that they will produce in an unforeseen way through the passage of time. What we need is to develop, transmit, and reconfigure the capabilities in theory, social or natural science, and practice whenever necessary. This is about capabilities transmission and dynamic capabilities rather than information asymmetry and incentive misalignment.

However, the problem is that science is still shattered into discrete disciplines such as economics, sociology, biology, seismology, physics, chemical engineering, political science, radiology, immunology, and law obsessed with a narrow-minded professionalism. This factionalism seems likely to prevent us from crossbreeding knowledge across the disciplinary border. In particular, the case of Fukushima suggests that the number of the tasks for

⁵Business ecosystem is “the community of organizations, institutions, and individuals that impact the enterprise and the enterprise’s customers and supplies” (Teece 2009, p. 16), See also Iansiti and Levine (2004).



Note: Checks represent the items of natural science.

Figure 1. Some Issues Along the Timeline for the Case of Fukushima

natural scientists would increase and the tasks *per se* become too complex to categorize into a discipline as time passes. This is shown in Figure 1. Thus research on corporations (Aoki 2001, 2010; Deakin 2011) and business ecosystems (Teece 2009; Pitelis and Teece 2010; Taniguchi 2012) requires a trans-disciplinary approach that integrates diverse research outcomes of institutions and humans in relevant fields. In the ordinary world, corporations and business ecosystems evolve independently of the disciplinary border that academics have deliberately established and unilaterally tried to impose on them.

Moreover, the figure shows that multiple institutional failures at *ex-ante* stage combines with natural disaster to yield the catastrophe at *ex-post* stage in the case of Fukushima. This is the simplest way of explaining the nuclear catastrophe. The case of Minamata has a different, but similar structure in that it lacks natural disaster, but multiple institutional failures are the main cause of the chemical catastrophe.

In general, the corporation and the business ecosystem could be regarded as an endogenously emerged rule of the game that influences human cognition and human actions. Thus we suggest that they are institutions or social technologies in the sense of Nelson and Sampat (2001), which enable people to economize on collecting and processing information and coordinate their expectations and actions.

But the problem is that institutions often fail even in a dynamically changing environment. Institutional failure occurs in the spheres such as the market, the firm, and the government (Pitelis 1991, 1995). In general, the firm solves market failure, the government solves the failures in the private sector consisting of firms and markets, and the private sector solves government failure (Pitelis 1995). However, it is likely that several institutions quite often fail at the same time and then the combined failure of institutions would occur.

Therefore we need to focus on three issues on institutional failure along the timeline. First, does market competition function well enough to develop different capabilities and give people a variety of options? In general, the market belongs with diversity and freedom to choose. When there is competition among firms, the market can develop and accumulate thicker capabilities over time and thus the vanishing hand, namely the market on the basis of outsourcing, modularization, and standardization, prevails in an economy (Langlois 2003, 2007). Secondly, do firms engage in the innovative activities that enable them to enjoy Schumpeterian rents? Otherwise, the firms are obsessed with the sustenance of obsolete business models or outdated routines which no longer function well in an ever-changing environment. In a sense, this serves as a litmus test to see if a firm traps itself in a program persistence bias (Teece 2009). The bias refers to the funding of obsolete programs beyond what can be sustained on the merits and is caused by the influence of program adherers. It results in the backset of innovation. Thirdly, is there some collusion between the firm and the government? If so, it is likely that the regulated (firms) involve the regulator (government) to distort the regulations in a preferable way to the industry (Stigler 1971). Such regulatory capture is a kind of government failure.

Looking at multiple institutional failures historically implies that the catastrophe had already begun at Fukushima before it came out in reality. In this sense, it is not necessarily correct to say that the Fukushima nuclear crisis did occur on 11 March, 2011. As Taniguchi (2012) attempts, the crisis smoldered and should be explained in terms of the social technologies (multiple institutional failures), the physical technologies (lack of capabilities necessary for operating nuclear plant), and the context (earthquake and tsunami). In the following, regarding multiple institutional failures as the main cause of the catastrophes, we will attempt to untangle the tangles of Fukushima and Minamata and facilitate capabilities transmission from the latter to the former to address the emergent issues at the *ex-post* stage, which could threaten the sustainability of the nation and Earth, by mobilizing a wider set of knowledge from social and natural scientists, practitioners, and policy makers all over the world.

Why Did the Catastrophes Occur? Case Studies

Minamata Disease: I.

Minamata disease is a neurological syndrome caused by severe mercury poisoning due to plant effluent at Minamata factory of Chisso. The origin of Chisso goes back to the early 20th century when two companies were established by Shitagau Noguchi. In 1907 Nihon Carbide Company launched producing carbide at Minamata to use surplus electricity which was generated by hydropower generation facility of Sogi Electric Company. In 1908 these two companies were merged as the Japan Nitrogenous Fertilizer Company, which was renamed Chisso in 1965.⁶

At that time, Minamata was a small village whose main products were salt and candle, both of which were moving into decline. As some village people heard that Noguchi, the young entrepreneur, was searching for land for industrial use, they went straight to him to ask for building a factory in Minamata to achieve regional development, giving him a sweet

⁶Thus it is strictly correct to say that the company caused Minamata disease is JNFC, but we prefer “Chisso” which is more popular name among people. Hereafter, we will refer to the company as Chisso even before it was renamed.

deal with the establishment of power poles, the irrigation rights of the Minamata river, zero land cost of saltern, and so on (Ui 2004). Thus attraction of the enterprise was done by the village people with emphasis on condition in its favor.

Around the 1940s, the company produced artificial petroleum for battleplanes with its state-of-art technology. 60% of its products were for military demand at that time. This gave the people of the company a sense of self-worth that “it is us that supports Japan”. In fact, who was eligible for job interviews was the one with a reference letter by a supervisor at University of Tokyo, which was allegedly the best university in Japan, to certificate being the best student in the department of applied science.⁷

Chisso succeeded to produce acetaldehyde with acetylene in the presence of mercury as a catalyst in 1932. The annual production was 210 tons in 1932, but it soared 18,100 tons in 1957 and 45,200 tons in 1960. From 1932 to 1968, an estimated 25 to 30 tons of mercury compounds were dumped into Minamata Bay by the Chisso acetaldehyde plant. The compound responsible for the Minamata disease is methyl mercury, an organic salt of elemental mercury, which bioaccumulate in living organisms. Organic mercury compounds are among the most toxic compounds known and are much more hazardous than the elemental mercury. Dimethyl mercury, for example, is one of the most powerful neurotoxin known. The death of Professor Karen Wetterhahn at Dartmouth College in 1997 made headlines. It was caused by the spillage of few droplets of dimethyl mercury on her latex gloves. The compound penetrated through her gloves, skin and entered her brain causing irreversible neurological damages, which led to coma and few months later death. The danger of organic mercury compounds has long been known. In 1865, two English laboratory assistants died several weeks after helping synthesize dimethyl mercury for the first time (Nierenberg *et al.* 1998).

The production of methyl mercury in the acetaldehyde process has never been fully explained. There are two important questions on the Minamata disaster that have been explained only recently. The first is about the beginning of the disease. Chisso had been producing acetaldehyde into Minamata Bay since 1932; however, the first symptoms of the disease appeared in 1953. Moreover, seven factories in Japan and twenty all over the world produced acetaldehyde using the same process and discharging waste water into fished water bodies. However, in those cases no resounding case of mercury poisoning has been reported. Some scholars (e.g. Nishimura 1998; Nishimura and Okamoto 2001) attribute this to a change in a procedural step in the process. The process to make acetaldehyde involved contacting acetylene and water in sulfuric acid containing mercuric sulfate at 50 – 100 °C. In August 1951, ferric sulfide was substituted for manganese dioxide, which had been used as a promoter for maintaining the activity of mercuric sulfate catalyst. The ferric sulfide allowed a side reaction to occur in which methyl mercury was formed. The methyl mercury concentrated in the waste stream from the process and was discharged into Minamata Bay. The introduction and bioaccumulation of methyl mercury into the food chain, starting from sea organisms, caused what is today known as “Minamata Disease”. Its major symptoms include sensory disturbance, ataxia, concentric constriction of the visual field, and auditory disorders. If a mother is highly exposed to methyl mercury during pregnancy, her baby might suffer from fetal Minamata Disease, which sometimes shows different symptoms from the adult one. The disease affected humans as well as animals. Cats were seen to go mad and die, birds were seen to suddenly fall from the sky. While cat, dog, pig, and human

⁷See Ui (2004, pp. 62–63).

deaths continued over decades, the government and company did little to prevent the pollution. At the end of 2005, 2,955 people had been recognized as having the disease, of whom 2,002 have died, according to the Environment Ministry of Japan.⁸

The quantity of methyl mercury compound obtained as by-product in the production process, which was actually the root cause of Minamata disease, increased and thus the contamination of Minamata Bay worsened. The company kept on taking the lion's share in the market (Harada 1972). Thus it became known as "technological Chisso". At the same time, it is likely that this might have rendered the people of Chisso arrogant and over-confident. The company attempted to be a step ahead of the competition by taking a chance on introducing a risky technology into their experimental factories. Their attempts could be taken as entrepreneurial, but actually caused many accidents and explosions. It would be fair to say that this reflected their culture that "keeps workers on the trot, treating like cows and horses" (Ui 2004, p. 67).

As the case of Minamata illustrates, the pollution occurs after the destruction of the environments by humans for years. There occurred damage to marine-related products around 1926 or 1927 in Minamata due to the operations in chemical business at Chisso. In 1949, the Minamata fishermen's cooperative association was established to dish out complaints to the company that fish hauls decreased. But the company totally neglected their voices against the chemical production and its possible damages to the sea environment, asserting that the fact was not scientific and lacked concrete evidence (Harada 1972).

What appeared to be Minamata disease was first reported in Kumamoto *Nichinichi* Newspaper on 1 August, 1954. As all the cats in a Basti of Minamata went to the wind due to epilepsy, the number of rats dramatically increased.⁹ After some two years' silence, on 16th May, 1956 the newspaper reported that there occurred fascinoma for children in Minamata.¹⁰ Actually, on 21st April 1956, a 5-year-old girl was seen in the pediatric department of the Chisso Minamata Factory Hospital because of gait disorder, lalopathy, and mania. She had to admit herself to hospital. To be worse, on 29th her 2-year-old sister had to be hospitalized with exactly the same symptoms. On 1st May, Hajime Hosokawa, the director at the hospital, formally reported to the Minamata Health Centre that central neurological disease of unknown etiology reached epidemic proportions. Thus it has been acknowledged that that day is really when the disease was first discovered. But it would be more reasonable to say that what was known as weird disease among the village people was actually the Minamata disease.¹¹

The Kumamoto University Research Group (hereafter, KURG) was organized on August 24, 1956 to investigate into the causes of the disease. The researchers started visiting Minamata on a regular basis and admitted patients to the university hospital for detailed examinations and diagnosis. On November 4, 1956 the research group announced its initial finding such that the disease is considered to be poisoning by a heavy metal and it enters the human body through fish and shellfish.¹² As soon as they considered a heavy metal the causal substance, the effluent from the Chisso factory was immediately suspected as the origin of poisoning. But the wastewater contained many heavy metals such as manganese,

⁸ See <http://www.japantimes.co.jp/text/nn20060221f1.html>.

⁹ See *Kumamoto Nichinichi Newspaper* (1 August, 1954).

¹⁰ See *Kumamoto Nichinichi Newspaper* (16 May, 1956).

¹¹ But the survey by Kumamoto University showed a case of alleged pathogeny in 1942. Later, the hypothesis that Minamata disease has occurred since 1953 became dominant, but as the patients did not realize that they suffered from the disease, its discovery was belated unfortunately. For this, see Harada (1972, pp. 144-147).

¹² See Harada (1972, p. 22).

mercury, selenium, and thallium. Identifying which particular material was responsible for the disease proved to be hopelessly difficult. Thus many different theories were proposed by different researchers at that time.

[To be continued later]