How research and innovation policy withstand disruptions: Japan after Fukushima

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Japan was the first nation in the mid-1990s to respond to a systemic crisis by the design and implementation of a long-term and large-scale science and technology policy. The goal was to generate innovation in order to create new epistemic conditions of economic growth and social progress. Most industrial nations have since then developed similar policies with the goal to overcome a "long-term recession". In Japan, this policy led to successive Basic plans for science and technology policy; the last one, the 5th, was launched on January 2016.

In March 11, 2011, Japan was confronted with another massive disruptive event, the Fukushima catastrophe. The *source* of the catastrophe was a giant earthquake and tsunami. The problem is to analyze how a large-scale research and innovation policy responds to a disruption, which has for *origin* the networks of political and economic power, which brought together the conditions of the catastrophe. Because the population has lost trust in government and the state apparatus, economic policies to overcome stagnation remain inefficient.

The problem is to examine how a large-scale research and innovation policy can internalize such context and build the conditions of its performance. Comparing the successive plans and their different objectives shows how this problem was addressed but also denied. The goal is to open research on a different type of research and innovation policy.

Keyword ——— Long-term recession, Japan, innovation, research policy, Fukushima, disruption.

Introduction. Innovation in question

Innovation has been for many years the magic wand of advanced industrial societies, of the hybrid network directly concerned with science and technology. This network connects members from the relevant ministries, university researchers (including those in social sciences specialized in the field), and business leaders of technology-oriented industries. However, the present systemic crisis is spreading disenchantment with innovation throughout the world. This disenchantment is best expressed by the notions of "secular stagnation" and "long-term recession;" many believe that innovation alone will not be able to restart economic growth and deliver its promise of social progress.

I examine this pessimistic diagnosis by studying how innovation policies are supposed to respond to the present systemic crisis. I focus on Japan, for two reasons. First, Japan's trajectory since the 1990s is paradigmatic of policies for restoring economic growth being implemented in all advanced industrial societies. Second, the Fukushima catastrophe is a disruptive event the extent and meaning of which remain, in my view, largely unknown. Disruptive events reach so deep in a socioeconomic system that they make possible a transformation of social evolution. Based on these two premises, I examine the context and conceptual presuppositions of Japanese innovation policies . These cannot be reduced to issues of technological or economic progress, nor can they be separated from their social, political, economic, and cultural contexts. This is why innovation as a *policy* is inseparable from all inclusive research and innovation policies. These policies are huge institutional constructions resulting from negotiations among government and the state apparatus, heads of universities, academic experts, and business communities. These conceptual constructions are based on a few models and theories. The performance of these policies does not depend only on the size of the budgets allocated to their programs, on the innovative quality of the research these budgets finance; rather, it is largely determined by the institutional context in which they are designed and implemented. This institutional context needs to become an object of research and debate concerning policy design and evaluation. The case of Japan shows that, because of their scale, these inclusive policies are regularly derailed by unpredictable events. For all these reasons, these policies always fail to establish the ground of the next ones. They always remain unachieved and pile up on top of each other. Research policies are more the long-term trajectory of a given socioeconomic system than successive stages (progress) of techno-economic development. The time has come to question what a research policy is, what is expected from it, how it can assimilate unpredicted events, and where it is leading society. A large-scale research policy is also a form of politics.

This problem is addressed in a disruptive historical context. For Japan, 2015 was an opportunity to remember significant contemporary events and an unresolved issue: in 1985, the first *endaka* (rise in the yen) brought a sudden end to the post-war economy. The bubble economy ended in 1990,

and Japan's first long-term recession began. Then, 1995 began with the Kobe disaster on 17 January, and a sarin gas attack was committed in the Tokyo subway by the Aum Shinrikyo sect on 20 March. Later the same year, the Basic Law for Science and Technology was passed, which revived the will to generate a new wave of economic growth and social development based on scientific research and technological innovation. By the fall of 2015, the will to design and implement a science and technology policy was fully alive, but it proved to present a complex challenge. Everyone was thinking about how to commemorate the Fukushima catastrophe of March 11, 2016. This event was forcing everyone both inside and outside Japan to debate its full meaning. History shows that an event of such magnitude always ends one period and begins a transition toward a new one. For Japan, a page of history was turned even before the catastrophe, in the early 1990s, when what seems to be an endless recession began. The 2007/8 systemic crisis intensified uncertainties at all levels. In 2017, the main constraints are the current economic crisis, climate change, and growing international instability and security problems. This conjuncture is addressed in the first sentences of Japan's Fifth Science and Technology Basic Plan announced on January 22, 2016: "Our country and the world are in the midst of an upheaval. The question is whether science, technology and innovation (STI) can contribute to sustainable and inclusive development here and abroad. The Fifth Science and Technology Basic Plan is expected to be the answer to this question and provide a compass that will guide the Japanese people, as well as people across the globe, to a more prosperous future." In this paper, I do not study the plan itself but its promise concerning innovation. I ask how an innovation policy can deliver its promise to extract a nation like Japan from its long-term stagnation.

My answer needs to be situated. I do not pretend to possess a final answer or solution. I am just trying to change the perspective on these matters, based on the role played by science and technology studies in human and social science research.[1)] To study innovation today is to situate research and innovation policies in their institutional contexts. This has become the *epistemic condition* of all advanced industrial societies. Since the late 1990s, they have all developed similar innovation strategies in order to sustain economic growth and competitiveness. The problem is, therefore, not the innovation policy of a given nation as much as the interactions among these different innovation strategies (Rieu 2008). This comparative perspective is the basis of this paper.

1. The innovation enigma

The *OECD Science, Technology and Industry Scoreboard 2015* proves once again that the solution of last resort for overcoming the ongoing systemic crisis can be found only in "frontier technology" as the source of industrial innovation. Industrial innovation is supposed to sustain or save mature industries and to create new ones, new companies, and new jobs; these will pay taxes, which will in turn

finance public services, social policies, and research and innovation policies. This magic circle, or virtuous spiral, looks unfortunately like a steam engine trying to fight its own entropy, thus embodying a new version of the prophecy made by Oswald Spengler in the early 20th century—of a decline, not of the West, but of industrial (i.e., modern) society.

What is emerging now, in early 2017 as I reread this paper, is a growing awareness that this crisis will not end, that advanced industrial (i.e., mature societies or late capitalist) societies are not evolving toward a reformed version of their "initial state" before the crisis. This explains why this crisis is considered proof that advanced industrial societies have entered a "secular stagnation" (Summers 2013), or at least a "long-term recession" (Gordon 2010). They cannot expect to ever again enjoy the growth rates that that had experienced since the 19th century because that high growth was generated by a unique aggregate of a series of technological discoveries. They cannot even expect to return to the growth rates of the 1950s and 1960s, of the post-war reconstruction period. In other words, mature societies should renounce all hope of restoring their historical virtuous spiral or of inventing a new one (Streeck 2014). This virtuous spiral could happen only once. The cause of the present recession is the high improbability that a new technological wave will generate another long period of growth. Another reason is that advanced nations have reached such a high level of development that no technology, however disruptive, could generate a level of growth so high that it would radically transform the economy, the institutional system, or even the culture. Digital technology is certainly a disruptive innovation with deep economic and social consequences, but it did not generate a disruptive growth level.

The case of Japan shows why this systemic crisis is not a postmodern dead end but a transition toward another type of social and economic system. It also shows how difficult this transition is—difficult to conceive and even more to manage and achieve. The notion of "systemic crisis" is more inclusive, descriptive, transdisciplinary, and explanatory than the notions of "secular stagnation" or "long-term recession." It requires us to identify the components of this system and their interactions, the parameters and sequences of a crisis, which erupted in the US in 2007 before engulfing Europe and Japan in 2008 and finally the rest of the world. This crisis is systemic because, under the growing constraints of climate change, it was first financial, then social and economic, and finally monetary, political, and even geopolitical when it concerned energy supplies and costs—leading in 2015 to a huge wave of immigration from authoritarian countries and failed states to democratic states in Europe and their rule of law and market economies. Such a level of complexity is beyond control and seems unmanageable.

From this perspective, if innovation means anything, it cannot be reduced to technology alone. If innovation is our collective response, what it really means is far from clear. Whatever is

supposed to happen between the source of innovation and the river of growth and welfare remains, after years of study and debate, hidden in a black box. “Innovation” is our mantra, used by governments and companies as a magic wand to solve all problems, but magic wands and their gurus explain very little. Innovation is primarily a question of collective practices developed through institutional arrangements that link companies, universities, and governments. Good practices are not found in any single one of these institutions but in their connections and interactions. These interactions cannot be reduced to any method that can be copied, taught, and then applied. They remain largely informal, making them difficult to study in detail and thus difficult or impossible to replicate, adapt, and adopt. Why some methods and practices are inefficient has proven equally difficult to study and explain.

Paradoxically, in such concrete cases, concepts and theories prove extremely useful. Conceptual innovation matters. Concepts are not drawn from nowhere. They carry experience. They are constructed through mental experiments and case studies. One of the most powerful and influential conceptual innovations produced in the last 20 years is the “triple helix” concept developed by Henry Etzkowitz and Loet Leydesdorff (1998) and derived from a powerful theory synthesized in the concept of the “national innovation system.” When the current systemic crisis, intensified by growing environmental constraints, was interpreted through the triple helix concept, new versions of this concept had to be formulated. New research on the concept is proving its continued heuristic value and evolutionary potential.

These circumstances questioned the established reference and standard found in Silicon Valley. However successful it might be, Silicon Valley is neither “a global model, nor a unique anomaly.”[2] It certainly was an inspiration, but constructing Silicon Valley into a model proved to be a vain and costly enterprise. The study of Silicon Valley led to a more precise understanding of the singular conditions of its emergence and reinvention. Since the mid-1990s, as the triple helix model proved increasingly influential, it has also provided a method of analyzing and evaluating the Silicon Valley phenomenon. The same model explained how Europeans, South Americans, and East Asians could find their own solutions for generating innovation and industrial growth. The evolution of Silicon Valley since 2000, the burst of the Internet bubble, research on the San Francisco Bay area and its long-term future beyond ICT,[3] and debates about the triple helix model allow us to redefine the model according to its various implementations and interpretations.

Thus, environmental constraints and the current systemic crisis have transformed the conditions for research and innovation in all industrial nations. In describing the situation and finding solutions, the triple helix model has had a strong influence at the regional, national, and local levels. However, interpretations and implementations of the model differ widely according to the context. In today’s post-Fukushima context, comparing versions of the model enables us to redefine the model

itself. Furthermore, the 2002 Triple Helix Conference in Copenhagen and the report by Loet Leydesdorff and Henry Etzkowitz (2003), "Can the 'Public' Be Considered as a Fourth Helix in University–Industry–Government Relations?" have opened the way for new research on helix theory, which is proving particularly relevant. What is at issue is defining this fourth helix—what "public" or "society" means in this context.

2. Japan's context: two intertwined systemic crises

The goal is not to write the history of Japan's science and technology policy since the 1990s but rather to extract from the case of Japan a conceptual prototype, a full-scale experiment on the introduction of "society" within an institutional arrangement organizing the interactions between universities, the state apparatus (including government), and the industrial structure. This Japanese experiment was born within a specific context. A parallel has to be made between two systemic crises: that in Europe and Japan since 2008 and that in Japan since the 1990s.

The trigger of the current systemic crisis in Europe and the rest of the world was the 2007 American subprime crisis. This crisis is in turn based on the US debt that had been mounting since the 1960s and was intensified by the savings and loan crisis of 1987. The US subprime crisis disrupted the European financial sector in 2008, with strong ripple effects across all industries. Each European government decided to save its financial sector by nationalizing its debts in order to restore or sustain its capacity to finance the economy. This policy revealed each nation's high level of debt and deficit and relative powerlessness to cope with the situation. A financial crisis born in the US was in a few months changing the global financial criteria , which European governments had to implement but could not satisfy without disruptive consequences for their economies and societies. They found themselves reducing their sovereign debt and deficits at the risk of low growth, deflation, and high unemployment.

Similarly, Japan's economy and society went into systemic crisis in the second half of the 1980s, with the full crisis erupting in 1991/2. The trigger was the first *endaka* after the Plaza meeting of the G5—France, West Germany, Japan, the US, and the UK (i.e., the US and its postwar allies)—on September 22, 1985. The value of the US dollar to the yen dropped 51% from 1985 to 1987. The long-term cause of the crisis involved Japan's postwar reconstruction policies coordinated by the state apparatus under the guidance of the MITI and an advantageous yen–dollar (as well as Deutsche Mark–dollar) exchange rate established by the US government to facilitate the reconstruction of the economy of these two critical allies and quasi-colonies. In the early 1980s, when the American administration under President Reagan faced a steep appreciation of the dollar, it began to criticize Japan's "unfair trade practices" and asked repeatedly for an adjustment of the exchange rate with the yen. The

Japanese administration promised action but delayed it. The decision was taken unilaterally in 1985 to devalue the dollar. The competitiveness of the Japanese economy was violently impaired. At the same time, the value of the yen and of Japanese assets soared; this created the bubble economy, which was finally gotten under control by the Japanese government in 1991.

The US administration and the other members of the G5 did not anticipate the full consequences of the *endaka*. It gave the Japanese economy enormous financial resources, which were invested across East Asia but mainly on the Chinese coast, where production was transferred to reduce costs. It contributed significantly to the rapid growth of the Chinese industry. This unexpected situation led to the second *endaka* of 1995, when the yen reached its highest rate since 1945 of 79 against the dollar. The Japanese banks were forced to sell a large part of their assets in East Asia and to repatriate their funds. This momentarily reduced Japan's economic influence in East Asia. This second *endaka* had the unforeseen consequence of creating a crisis across East Asian economies, which generated a worldwide crisis with major consequences in Russia, Argentina, and South America. The other unanticipated consequence, or perhaps an intended consequence, was the deconstruction of the postwar Japanese social and economic system and the start of a yet-unfinished transition. These two sequences of events prove that the US is more dangerous to their allies than to their enemies, as their allies lack any real capacity to react.

3. Research policies as response to disruptions

To explain Japan's response to this systemic crisis, I need to introduce the major actor within an institutional context, the "power structure," which comprises individuals and groups from different sectors (public, private and civil) who had the collective capacity to negotiate, design, and implement policies. Since the mid-1990s, without following Japan's example, a similar response has been seen in many different nations, which find themselves in the situation Japan had tried to escape by designing this type of policy. Japan's power structure has been trying since the 2006–2008 period to overcome the "long-term recession" by implementing a version of a quadruple helix, defined and justified as "society." My second goal is to evaluate how Japan's solution can become a theory and paradigm, how Japan's science and technology policies are considered the key responses to a systemic crisis, and how these policies follow a trend in which "society" is considered a problem and a solution for reshaping these policies to form a different social and economic system. Studying the case of Japan is relevant for all advanced industrial societies.[4)] A further task is to examine what "society" is for such a social and economic system?

Since the late 1980s, Japan's science and technology policies have had the explicit objective of organizing and managing this institutional arrangement in order to establish within the nation a full

research and innovation process ranging from basic science to the industrial production and commercialization of new or enhanced products and services. The scale and ambition of this project are remarkable. *Society* was of course always present and discussed in the forms of "social needs," "security," "collective infrastructure," and "everyday life." However, the role and conception of "society" have changed since 2006. I will focus on this change and attempt to understand what is at stake in order to determine if the introduction of a helix arrangement to it could be a solution (among many others) to the present systemic crisis and ultimately overcome the trap of the "long-term recession." This is not history but a conceptual construction based on this Japanese experiment.

In the early 1990s, the bubble crisis forced the administration to restructure Japan's national research and innovation system. The proliferation of and disparity among programs in the 1980s were costly and inefficient, and the benefits were far below expectations. Because of the number of partners (e.g., ministries, companies, universities) involved, the fields concerned, and the resulting redundancy, two large programs were organized: the Industrial Science and Technology Frontier Program and the New Sunshine Program for new energy sources and environmental technologies. This division shows that Japan's long-term priority was explicitly to respond to environmental constraints by articulating green research and industry in the hope of creating a different social and economic system. This restructuring led to a final reform that established a new and coherent research and innovation system. The goal was not simply to have a strong science and technology policy; the objective was to build this policy within the institutional system and to adapt the institutional system to the role and output of this policy. The consequence, perhaps the tacit goal, would be to reshape the social and economic system. The objective was to restore, rebuild, and sustain Japan's global competitiveness.

The Basic Law for Science and Technology was enacted in 1995. According to this law, three Basic Plans were developed from 1996 to 2011. Spending on science and technology increased from 12.6 trillion yen in 1995 to 17.6 for the first Plan, then 21.1 trillion for the second, and 21 trillion for the third. The size of these budgets says little about the plans themselves, or their construction, intentions, or internal dynamics. The first two plans had the goal of reforming Japan's system of research, innovation, and education. The third Basic Plan created a different dynamic: to transform the interactions between research and innovation activities with both society and the economy. The fifth Basic Plan was being constructed in the fall of 2015 and winter of 2016.

The first Basic Plan, from fiscal 1996 to 2001, had the goal of opening a new phase in which the public budget for science and technology would increase by 60% over five years. In spite of the crisis, the budgets were granted. The plan's priority was to modernize research infrastructures and create new ones. The objective of the second Basic Plan, from 2001 to 2006, was to extensively reform universities and the university system, to draw a line between public and private universities, and to

give public universities financial and administrative autonomy. Public universities had to become accountable for their management (including profitability) and their research and teaching performance. To stimulate research and open new fields, a Center of Excellence (COE) program was established in order to provide financial incentives for innovative projects on a competitive basis. The goal was to facilitate the emergence of trans-disciplines. The outcomes of these reforms were criticized due to unreasonable expectations. Many promising projects were ambitious and costly, but it was often a serious mistake to severely cut or even withdraw their budgets before they could prove that they deserved the initial support they had received.[5] The COE program has indeed stimulated innovative research projects in many fields.

The third Basic Plan, from 2006 to 2011, was launched in March 2006.[6] Its conception and goals were different. It was based on a large inquiry designed to identify both the worldwide state of research and the needs of Japan's population. The goal was to respond to the economic and financial situation by taking into account Japan's social constraints: the aging of the population, the demographic decline and low birth rate, the rising cost and scarcity of energy and environmental constraints in general, the increased competition with China, and growing international instability. From my point of view, the Third Basic plan was explicitly introducing a fourth helix to Japan's research strategy. In mid-course, however, the Third Plan was disrupted by the 2007 crisis. Japan was hit where it hurts the most. With great difficulty, its economy had been partially restructured and, in 2004/05, had begun to grow again, but the 2008 crisis proved how fragile this growth and recovery were. High-tech industries were far too dependent on foreign markets and global economic growth. The time of an export-oriented economy based on ever-growing value-added industries and products could no longer sustain Japan's long-term economic growth and social development. All industrial nations, including the US, had been implementing the same strategy, which was also becoming a dead end for them. Japan found itself caught in a mimetic trap, but nobody knew, and nobody knows, how to do things differently. The resulting adaptation and revision led to the conception of the next Plan, the fourth Basic Plan, but the Third Plan expressed what should be called the *social turn* of science and technology policy in Japan. Japan was in fact the first industrial nation to initiate this turn or even face this problem.

The fourth Basic Plan was supposed to be launched in April 2011. Because of the crisis and the resulting recession, discussions had been more inclusive because this plan would have to make a significant difference in order to justify the same level of public funding. The population would have to see the difference in its daily life, standard of living, and public services. According to available documents, the plan intensified the Third Plan's orientation toward solving pressing social problems. Small and medium-size companies and new industries, jobs, and services responding to the present

needs of Japan's population would have to be created or reinforced. The trend toward a quadruple helix arrangement was confirmed. The Fourth Plan raised expectations: results had to be experienced by all those concerned—by the business community and by civil society. Universities had to innovate and transfer these innovations to the core of the economy and society. Tangible results were necessary because various polls and studies were showing a growing public disenchantment with large-scale science and technology policies. The results would have to be judged according to the criterion of "social accountability." Overall, innovation had "to make sense," to generate growth, create jobs, and satisfy real needs. Innovation could no longer be a promise about the future but about the present. Behind the marketing and political slogans, a real problem emerged through Japan's techno-structure: the 2007–2011 crisis required a profound revision of an economic strategy designed in the early 1990s and based on scientific progress and technological innovation. Society was the intruder and, ideally, part of the solution.

There was no alternative. Something had to change within the strategy itself. The introduction of a fourth helix is both the problem and its solution. Intense debate has taken place since 2008 and a consensus has slowly emerged.[7] It was politically sensitive because it reinforced the divide between a social-democratic approach and a conservative approach, which, in Japan, expresses the interests and perspective of the state apparatus. Nevertheless, the "social turn" was not an ideological or partisan choice but a response to existing, but tacit, constraints enforced by the systemic crisis. Every industrial nation, both mature and new, has the same innovation strategy, which ultimately relies on and is justified by exports in a state of global economic and social crisis reinforced by environmental constraints. The social turn is an effective version of the fourth helix: it opens perspectives that are obviously worth exploring. Japan was the first to arrive at a dead end it has to pass through. To be the first to find a solution is a risk but also, potentially, a major competitive advantage. It is a theoretical and pragmatic challenge. There seems to be no other solution: world markets for the type of exports produced by Japan and other advanced economies are reaching saturation. To produce cheaper or lower-tech exports only exacerbates competition and reduces the growth potential of new industrial nations while failing to generate enough profits to sustain the level of consumption and services of advanced economies. All these problems are intensified by the need to advance in the energy transition, which will soon transform social behaviors and values as well as economies.

According to this "new paradigm of innovation," in order to help the Japanese economy and society, the designers of such research and innovation policies have to learn how to articulate and manage different goals within the same policy. These designers and shareholders need to come from all sectors of the social system. The methodology will have to derive from deliberative democracy via a prospective and constructive approach.[8] These policies have also to respond to local practical prob-

lems and sustain world-class research. This requires innovations in research governance, a new way of conceiving, organizing and managing research and innovation processes. Again, what "society" means in this context is more complex and comprehensive than usual conceptions and practices. It leads to a new version of "civil society," with a different role and responsibility internalized in policies shaping the evolution of a whole social system.[9] Nobody really knows yet how to fulfill this task or to design the institutional arrangements it requires.

However, we know from the case of Japan that the new arrangement is a search for new interactions among universities, firms, and the state, and that these interactions cannot find solutions within these poles of activity alone. Various documents, debates, and reports[10] show that the goal is not to (as usual) put new products on the market in order to respond to a potential demand. Opening new shopping malls everywhere is not a solution, just a rush to excess commercial and production capacity, deepening the crisis and wasting capital in speculative and unproductive investments. The goal is to identify social needs as well as individual desires and collective aspirations, to meet societal criteria, and to try to satisfy these needs and desires by creating new products and services in different types of "market" or exchange modes. At least one thing is certain from this perspective: the neoliberal "market" is no longer the center of the social system. Society, people living their daily and ordinary lives, has become the center of society. We, the people, cannot be reduced to consumers or users, though we do consume and use. The problem is no longer to organize and reform a "national system of innovation." Obviously, Japanese debates and research show that the problem is to negotiate and organize the emergence of a new "innovation ecosystem" within society itself and from the point of view of society.

The "innovation ecosystem" notion is confusing: it names a problem without solving it. It is a black box within a black box. If one tries to extract its practical meaning, it denotes continuous, intense, and sustainable interactions between different actors reflecting the various functions or sectors of the social system, even that of social "shareholders."[11] This is not only a version of the fourth helix but is a different helix model. In this sense, the idea of a Basic Plan becomes obsolete and could be replaced by continuous and inclusive research and innovation processes. This remains a conceptual experiment, but the evolution of Japan's social and economic system through all-inclusive research and innovation policies has reached a stage when conceptual experiments make sense and become a real institutional issue. It reminds us all that Japan has been a full-scale laboratory since the 1980s. What is at stake is clear: to gather into a constructive debate various actors and partners from different sectors with different interests and values. This vision remains vague and largely rhetorical, but something happened that gives it meaning and content. The Fukushima catastrophe has changed the whole landscape. From the perspective established throughout this paper, Japan has no choice but to proceed

and innovate in a direction from which no return is possible. Fukushima is the tipping point.

4. The Fukushima catastrophe: Japan's black hole

No return possible? If this extreme disruption is not translated into new policies, the whole nation risks stalling in denial. It risks losing the opportunity to overcome the long-term recession. The Japanese government under Prime Minister Abe seems to deny the full meaning of the Fukushima catastrophe. His government intends to reduce the catastrophe to another mere set of constraints. The reasoning is well-known: an accident or defeat (this military conception is common) has happened, but history cannot be rewritten; one has to live with it and move ahead. It is a type of denial. The solution is always to learn from what happened. The scale of the Fukushima catastrophe and its full meaning for the Japanese nation, economy, and society are impossible to deny. Denial would imply that the nation is stuck in a situation that has become unreal because it has been transformed by the catastrophe. The evolution is blocked. The people, including the politicians, seem to live in a reality that no longer exists. This perverse situation is dangerous; it intensifies a sense of collective frailty and personal anxiety because the catastrophe is like a ghost looming over the whole country. A catastrophe of this magnitude transforms a society radically, like a tsunami transporting a social and economic system to another stage of its history. Instead of denying the catastrophe and freezing Japan's evolution, it would be more rational and efficient to debunk the causes and consequences of the catastrophe in order to turn the page without denial

This debunking has been ongoing since March 2011. The catastrophe was caused by neither the earthquake nor the resulting tsunami: they were just the deadly trigger for a systemic catastrophe at once human, social, political, technological, and industrial. According to the available information, the *networks of power* that decided where to build this nuclear plant and its six reactors were the cause of the catastrophe (Nishioka 2011, Hindmarsh 2013). This power structure selected the technology; it decided the standards for the plant's construction, maintenance, and backup systems, the security of the nearby population, and for protecting the environment, land, and ocean (Crowell 2011, Koide 2011). Other nuclear plants have been built in highly seismic regions. A collective investigation has established that the dangers and mistakes made were known and that information was available to the media, politicians, administrators, researchers, and other experts. This is not an accusation, just a summary of the collective investigation on what happened at Fukushima.

Since March 2011, a collective inquiry, including various Japanese media, has uncovered the different power networks involved and their connections (Samuels 2013). What *really* happened at Fukushima is a public exhibition of the power structure controlling and managing Japanese society and economy. This power structure is now naked and exposed. This power network links various

departments in the two powerful and competing ministries in charge of technological research and energy supply, the METI[12] and the MEXT.[13] It also includes the nuclear industry, utilities companies, and the industries that depend on these utilities companies—the electronic and mechanical industries (mainly the car industry), the chemical and metallurgical industries (including pharmaceutical and health industries), construction companies, and transportation industries.

This power network links all the industries of Japan's first and second industrial revolution—the industries that rebuilt Japan after 1945 and those that developed Japan in the 1980s. In fact, this power network owns and controls the infrastructure of Japan's entire economy and society. They are *heavy* and *hardware* industries.[14] As such, they manage the population and the national territory. Because of their size, the range of their activities and their accumulated wealth, these companies constitute a network of interests, which includes various factions in each of the main political parties, which they support and finance. The collective investigation has also shown how this power network includes the media, which are largely financed and influenced by utilities companies. Thus, this power structure constitutes what John Kingston (2012) called "Japan's nuclear village." The problem is that a closely knitted village tends to become a "Galapagos of power" (DeWit 2012). In the end, such a village becomes counterproductive: it generates a level of risk that no society can bear and no economy can afford in the long term. France is in the same situation.

This power structure emerged in the mid-1950s. By the early 1980s, as a response to the first energy crisis, it had accumulated the financial means, expertise, and political influence to transform its aggregated power into a nationwide nuclear industry, to build and maintain nuclear plants according to its interests and safety and profitability standards, to distribute energy, and to manage all the people and activities that depended on electricity. Nuclear energy was the perfect match for a strong and coherent power structure (Shiokura 2011). Only a power structure can decide to develop an industry supplying nearly one-third of the national electricity consumption. When all the long-term costs and risks are taken into account, no private company would consider such an investment rational.

The problem is therefore not nuclear energy as such but the institutional environment in which this technology is embedded and in which it was developed and is developing still. Science and technology studies have proven for years that the institutional environment shapes a technology. Today, six years after the catastrophe, the nuclear industry has not renounced its objectives: nuclear energy is still promoted as the best, most rational, and most economical core energy supply for Japan. Since the formation of the LDP government in January 2013, Prime Minister Abe has expressed his will to restart Japan's nuclear plants. He seems to be succeeding. To justify its role, this industry now claims to be managing a long-term transition between a fossil fuel energy system and the next, *green*,

system. This communication strategy is also found in Europe (e.g., Germany, France, Switzerland). Since Fukushima, however, the divide and loss of trust between the population and the energy-based industrial complex and the state apparatus have become so deep that the population rejects this policy and strategy as well as the power networks behind them. It is an emotional situation: post-Fukushima civil society has collected experience and acquired knowledge. The issue is not whether this policy is right or not but that this divide and knowledge, the public anxiety and deep mistrust, the shattered lives, and the contamination of land and sea are here to stay. People know that the "energy transition," however necessary, might be endlessly delayed. According to the post-Fukushima public investigation, the real danger for the Japanese population is the institutional system—the power structure controlling the Japanese economy, high-level administration, and political process.

Japan's future is at stake in the Fukushima catastrophe for several reasons. If the political parties do not seize this opportunity to reform Japan's political and economic system, the population will have proof, either tacit or explicit, that the state apparatus, government, and Parliament have chosen to take the side of the power structure and that they cannot expect anything but to remain caught in the unending crisis that started in the early 1990s and is ruining the nation's future. In these circumstances, Japan cannot be effectively governed. Policies cannot be expected to gain the minimum level of trust they require to be validated and followed by the population. Deflation would continue to destroy communities, families, and minds. During this downward spiral, big companies would resettle abroad, and the divide between the state apparatus and the population would become so wide that Japan might even cease to be a democracy.

Like many others, I clearly remember the moment in around 1996–98 when all textbook policies for responding to a crisis had been tried and had proven counterproductive. It dawned on us all that Japan was not facing a regular crisis, that there was little hope of returning to a reformed version of the initial situation. Everyone understood that they had entered a transition without really knowing where this transition was leading. Because of its history, there was anxiety but little fear because Japan had gone through similar experiences in the past, but the transition has kept on deconstructing the social and economic system. No policy seems to offer a reliable cure for these economic and social diseases. On one hand, the Fukushima catastrophe seems to seriously aggravate the situation and push Japan deeper into a black hole; on the other, the catastrophe might open a new avenue. The reasons are obvious: the debunking has occurred; people now know. Since March 2011, people know the causes of not only the catastrophe but Japan's long-term crisis.

These comments are superficial compared to the quality and precision of the debates, studies, and analyses published in the last six years. This accumulated knowledge is a real basis for reforming the social, political, and economic system. The task is complex and lacks any precedent .

The resistance is fierce. However, the knowledge is out in the open (Japan Focus 3/11). This knowledge is powerful because it is embedded in all those who produced it since March 2011—in the mothers caring for their children; people caring for their families, friends, and communities; journalists, researchers, teachers, and professors doing their jobs and fulfilling their responsibilities; politicians and bureaucrats understanding the real meaning of their duty; and even companies understanding their responsibility to their past, present, and future customers. This shared knowledge is *public* and occurs within the framework of "society," the fourth helix at work—a new conception of "civil society" and a real power within the social and economic system. These are not simply *words*; this is what has happened since the Fukushima catastrophe and what has made sense of this event.

5. Constructing the 5th Basic Plan for science and technology: toward a new research and innovation strategy

For Kamisato Tatsuhiro, Japan is "the canary of modernity." He is comparing Japan to the birds miners used to take down the mine to signal an imminent explosion. The bird would die just before the explosion. Many people died at Fukushima, but the deep civic trust the state apparatus (including government) needs in order to govern also died there . An exercise in reinvention every four years is the goal of Japan's Basic Plan for science and technology. In fall 2015, the 5th Plan was well under construction. Various documents had been circulating since the summer, and intense discussions were taking place in many agencies and think-tanks related to science and technology and directly in charge of designing these policies. My focus is on the policy's constraints, conception, implementation, and performance. The real benefits expected from these plans constitute a black box, as they depend not so much on the size of their budgets but on the intricate environment and unpredictable circumstances in which these plans are implemented. It is possible to outline the internal constraints that have and will impact the plan—the foremost being the knowledge of the *real* causes of the Fukushima catastrophe, beyond the earthquake and resulting tsunami.

As mentioned, the first Plan sought to modernize research infrastructures and build new ones. Beyond the usual research priorities, the second Plan sought to modernize institutional infrastructures; its main outcome was university reforms. The 3rd Basic Plan was the first one dedicated to science and technology, seeking to create research and innovation processes designed to reshape Japan's economy and society, as well as its foreign collaborations. It went beyond the opposition between top/down button/up. The research conducted to design the plan had been extensive. What was remarkable was the project to innovate by increasing the role played by social needs, societal requirements, and collective desires. The problem was not to identify new markets for products and services but to go one step further into society by using as a reference the evolution of Japanese society since

the 1990s, since the beginning of the systemic crisis. The deliberative methods for achieving this goal were not yet conceived, but a different type of advanced industrial society was explored based on different relations to "consumers" or "users" and the population at large. It did not pretend to be a dramatic alternative to American capitalism, but it was a Japanese version of the "knowledge society" based on innovative research.

The 3rd Plan was disrupted in 2008 by the crisis born in the US. Japanese political and business leaders were surprised that the economy remained so fragile after such a long crisis. They were disarmed by a global financial crisis that was destroying their foreign markets. This showed them that, in order to fully rebuild their economy and society, they would have to imagine an alternative to an export-based economy. The problem is that nobody knows how to do this. All these constraints aggregated and made Japan's situation increasingly complex.[15)]

A major political change happened in September 2009 with the election of the first prime minister from the Japan Democratic Party, Hatoyama Yukio. The 4th Basic Plan was conceived in an economic and political context different from that of the 3rd Plan, but its orientation toward a social and societal turn of science and technology was close to the values of the new political majority. The problem was to carry on the evolution begun by the 3rd Plan and to take into account the lessons learned from the 2008 crisis. The change introduced by prime minister Hatoyama was essentially conceptual. It was a change of values and methods more than of techno-scientific research topics. These conceptual changes made a difference. The first idea was to transform the crisis into an opportunity to reorient the Japanese economy toward new growth and innovation opportunities and to introduce political and social reforms. The second idea was to reorient innovation toward a green or greener economy, to redesign public services by strengthening health industries and technologies, and to develop a new and different energy policy. MIT was advising a similar evolution for the US innovation system.

There was nothing "leftist" about this orientation. It was simply a way to extract the Japanese economy and society from its extreme dependence on an export-based industry. In 2017, these orientations have become commonsense but remain difficult to implement. They met strong opposition. What made this political project controversial was its intention to emancipate Japan from American economic and technological hegemony by reorienting Japan's diplomacy and economy toward the formation of an East Asian sphere of common economic, social, and cultural development. These were long-term goals, and certainly difficult to implement in a time of severe crisis. Prime minister Hatoyama was trying to formulate a sort of economic, social, and political "new deal" for Japan. His government fell in June 2010, when he proposed closing the American military base in Okinawa.

All these ideas were expressed in the 4th Basic Plan, which was an adaptation of the 3rd Plan. The budget was increased, but the main reform was strengthening the role and authority of the

Council for Science and Technology Policy (CSTP) in the hope of extracting the research policy from political and bureaucratic control. The idea was and still is to build a research and innovation policy as the source of Japan's long-term social and economic evolution. The increased role of the Council for Science and Technology Policy is leading to an institutional arrangement, clearly a type of National Innovation System, whereby the government and state apparatus is retreating from (but not abandoning) full control of the policy, which is intended to create the nation's future knowledge conditions. Ideally, the CSTP would become a regulatory agency of government, sharing power with the industrial sphere and academic community. The *keidanren* was asked to participate and promote "open innovation" between academic research and R&D activities among Japanese firms. As anticipated, the answer was that academic research should take into account economic priorities and industrial challenges. This was a normal request and a typical negotiation managed by a National Innovation System. This institutional arrangement would constitute real progress and would transform the governance of Japan. It remains a model of evolution, if not a solution.

This 4th Plan was supposed to be presented at the Diet in late March or early April 2011. It was suspended for revision after Fukushima, but it could not be fully redesigned according to the new context. The situation was too urgent and complex to be incorporated into the existing Plan. It would have had to be entirely rewritten. The situation required a new type of policy. A new section was added concerning the reconstruction of the areas devastated by the tsunami, the relocation of the population hit both by the tsunami and the nuclear accident, the decontamination of the land and sea around the nuclear facility, and the management of the nuclear plant and its reactors. This new section also addressed the search for new energy facilities and sources to substitute for nuclear plants, which were shut down for inspection. This solution was approved by the government and voted on by the Parliament.

The first constraint on the 5th Basic Plan for Science and Technology was the 4th Plan validated by a political majority and withdrawn in August 2011, only six months after the Fukushima catastrophe. The full extent of the catastrophe was not addressed because it was caught between two different plans. Moreover, evaluating the historical meaning of such an event takes time because it concerns the whole economic and social system and the entire population. The debate on the Japanese energy supply, nuclear energy, the decontamination, the closure of the destroyed reactors, the dismantling and cleaning of the facilities, the storage of radioactive materials removed from the plant, cleaning of the contaminated soils, research on the potential contamination of Tohoku and of Japan itself, the living conditions of the population, the properties they had to leave behind, and other emotional, dangerous, complex, and costly issues could not be articulated as part of the core of a Plan. Much of the 4th Basic Plan for Science and Technology became obsolete after Fukushima. The strong ideas ex-

pressed in the plan were frozen. They were not an abstract invention, but an interpretation of Japan's evolution. They cannot be ignored and are similar to solutions debated and implemented in Germany, Northern Europe, and Switzerland: to renounce nuclear energy within 30 years in order to design a social and economic system based on a different energy mix. What is at stake is to overcome the power structure embedded in the present energy mix because it is blocking Japan's social and economic evolution and perpetuating its long-term recession.

The political majority changed in December 2012. The new majority, an LDP-led coalition under prime minister Abe Shinzo, sought to extract the Japanese economy from 20 years of recession, a destructive experience at all levels. His goal was justified. In order to achieve it, the cost of energy for industries and households and the need to control and reduce the increased trade deficit resulting from importing coal, gas, and oil were priorities. From the beginning, the Abe government intended to restart the nuclear plants, at least those that satisfied the new safety criteria and inspection standards put in place after Fukushima. After 2012, it was clear that his main agenda was to change the constitution. This agenda contradicted his economic policy: it further reduced the public support and trust required to restart the economy. To resume consuming, the Japanese people needed and still need to trust the objectives of the government.

Because the 4th Basic Plan had been voted on in August 2011, the new majority decided to leave the science and technology policy as it was. The idea was to wait for the mid-term assessment of the policy, from fall 2013 to spring 2014, and then evaluate the policy and start designing the next Basic Plan, the first to be designed under the Abe administration, according to its goal of extracting Japan's economy from its long-term recession and respond to the international and regional conjunctures. This situation is summarized in the first sentences quoted in the introduction explaining the guidelines and goals of the future 5th Basic Plan. This explains why the 5th Plan seems to overstep the conjuncture left behind by the 4th Plan—the extent and depth of the Fukushima catastrophe. The catastrophe is present, but the need to overcome its consequences reduces its real depth and meaning. This constraint is of such magnitude that the more its meaning is denied, the more it overwhelms all planning and forecasts. It has forever transformed Japan's future. Every catastrophe of this magnitude is also an opportunity to turn a page and produce major reforms. To reduce the meaning of the catastrophe is to lose that opportunity. This is exactly what Hatoyama Yukio explained in his inaugural address in January 2010, only seven years ago but already a long time ago, in the world before Fukushima. Japan's science and technology policies could never really unfold their projects and show their potential, but these layers of problems and experience, of concepts and projects, are still present in all who understand what research and innovation really mean for a nation like Japan.

Conclusion. Engaging complexity

The context makes the difference. Japan's context is certainly complex, but complexity should not impede action because it could increase uncertainty and unpredictability. Japan's conjuncture can be reduced to a dilemma: either the disruption is translated into a policy seeking to further the transition enabled by this disruption, or the plan or policy denies, not the catastrophe itself (how could it?), but knowledge of the conditions of its occurrence, meaning, and depth. In this case, the plan risks remaining "above ground," unanchored in the dynamic of the social system. This is what seems to have happened to the 5th Basic Plan: it has not yet become the basis or object of a full debate.

Societies change incrementally but they evolve according to their capacities to respond to successive systemic disruptions, to make sense of them, and to change according to this knowledge. Japan wears the scars of its responses to many extreme circumstances. It is its real strength, even if each step is exhausting the population. Each scar is the resolution of a conflict of power. Transforming a disruption into an opportunity is a collective task and a political duty. Japanese civil society has initiated the debate. When politics intends to repress such an opportunity, researchers, artists, intellectuals in general, have to step in. This paper seeks to prove that the design of a large-scale innovation policy and a disruptive event are not contradictory. The policy might seem a fragile illusion easily derailed or wiped out by a catastrophe or unpredicted event that transforms the conditions of its conception and implementation. On the contrary, however, an inclusive research policy might be the only way for a society to absorb a disruptive event, absorb the catastrophe, and overcome it by beginning a transition.

In the Fall of 2011, the Japanese social-democratic government realized that, given the scale of the catastrophe, deciding the future of nuclear energy required an extended and more inclusive democratic process. After a full *deliberative polling* was undertaken, the results were similar to expert advice: the recommendation was to close all nuclear plants in the next 30 to 50 years. The government decided upon this course and passed an enabling law. The Abe government rescinded this decision soon after taking office. Because it could not easily dismiss the public's stated opinion, the new government announced that the inquiry's methodology had been flawed. However, the Abe government has yet to restart nuclear energy production (Kobayashi 2015). The Japanese are deprived by their government and parts of its power structure of the ability to extract from the Fukushima catastrophe the reforms required to escape from the endless crisis that has been deconstructing its society and economy. In the case of Japan, an energy transition entails a political and economic mutation. There is no risk, but for the power structure. The nations that effectively engage an energy transition, like Germany and Switzerland, are not dreaming about fresh air and clean water: they tacitly but consciously build progress and advance by comparison to those (like France and Japan), which remain stuck in a

nuclear-based or carbon-based power structure (Rieu 2016).

In this sense, an inclusive research policy should include the full context in which this policy is negotiated and constructed, as well as the effective conditions of its implementation. This changes the perspective on research and innovation policies. “Large-scale” and “inclusive” take different meanings: science and technology do not include all aspects of society; on the contrary, all aspects of society are including research and innovation process. This is a decisive mutation: these policies become forms of politics by including society, the “public”, and the related debates and political processes. This is the evolution enabled by the introduction of a fourth helix.

One objection is that, because of their scale, research policies are indeed fragile, sensitive to disruptions to the point of being extremely costly, hard to evaluate, and ultimately useless. However, what makes them fragile is their complexity, which comes not from within but from outside—from their relations to their multiple contexts and their inscription within the life of societies. This complexity does not defy these policies but conditions their adaptability, which requires extended inquiries into the conditions of their conception and implementation. Conception *and* implementation constitute a good definition of design; adaptability is a question of knowledge.

The conclusion provides an introduction to a later paper. The design of an innovation policy should associate and include all segments of a society and spheres of activity (from civil society and academia to government and businesses) directly concerned with its contents and participating in its implementation. In this sense, policy design is a full exercise of democracy.

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Endnotes

1) This theme is the subject of my book, *Japan, an Unfinished Nation, Which Fails to Overcome Modernity* (Rieu 2013).
2) It was the title of the Triple Helix conference, which took place in Stanford on July 2011.
3) Information and communication technology.
4) In my book (Rieu 2013), this trend is interpreted as an experiment and the will to open a new modernization process.
5) I participated in several of them. Each one gave me an opportunity to work and debate with researchers from different countries. Various aspects of my present research on research policy, civil society, social sciences, and the theory of technology were elaborated within these programs in collaboration with Japanese and non-Japanese colleagues.
6) NISTEP Report (2005).
7) I have drawn from articles and presentations by Arimoto Tateo, former director of the Research Institute of Science and Technology for Society (RISTEX), Japan Science and Technology Agency, and from papers by and private discussions with Professor Harayama Yuko, during her time at Tohoku University and the OECD.
8) Kobayashi Tadashi (2014) has the experience and methodology to deal with this question.
9) The conception of "society" in Japan's disruptive technology programs like ImPACT is explained in a pamphlet available at http://www.jst.go.jp/impact/en/.
10) The RISTEX (http://www.ristex.jp/EN/) was created to explore a new type of helix arrangement. Today, its activities are more difficult to identify.
11) Watanabe Chihiro, Research professor, University of Jyväskyä (Finland), is developing a European Horizon 2020 project "Platform Value Now: Value Capturing in the Fast-Emerging Platform Ecosystems", which makes real progress toward solving some of these problems. An open (i.e., continuous) platform might be an efficient and cost-effective substitute for a plan. At this stage, it is not clear how what is meant by "society" is present in this version of an "innovation ecosystem." The idea of "capturing value" leads one to ask where "value" comes from.

12) Ministry of Economy, Trade and Industry.

13) Ministry of Education, Culture, Sports, Science and Technology.

14) These industries constitute the core of the *keidanren.* Their power and role explain Japan's relative weakness in software and why Japan was late in developing online industries and services.

15) To continue opening shopping malls seems a short-term and even dangerous solution. The fact that Japanese consumers continue to circulate between these malls does not mean they have the income and are ready to spend enough to support this economy. Obviously "money turns" fast in Japan because of its extremely low interest rates. This "arrow" does not restart an economy, however; it finances investments ready to turn into debt and "bad loans." It in fact deepens the recession.

「研究とイノベーションの政策」はどのようにして崩壊に耐えたか：フクシマ311以降の日本

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1990年中期、日本は長期的かつ広域的に科学技術政策をデザインし、それを実行することで全般的な危機に対応してきた最初の国である。経済成長と社会の進歩にとって新しい認識の諸条件を創造するためにイノベーションを生み出すことが、当時の目標であった。多くの工業国は、それまでの「長期不況」を克服するために類似した科学技術政策を発達させた。日本においては、この政策は一連の科学技術基本政策を通じておこなわれた。その直近のものが2016年1月から始まった第五次科学技術基本政策である。

それに遡る2011年3月11日。日本は福島第一原子力発電所事故という大規模災害に出会う。この大災害の〈原因〉は巨大地震と津波によるものであった。その際に〈起源〉としての政治経済権力のネットワークになり得た崩壊現象に、大規模な研究とイノベーション政策がどのように対処したのか、そして、それが大災害の諸条件にどのように合わさっていたかが問題になる。しかしながら政府と国家機関への人々の信頼が大きな失墜をしたために、不況を乗り切るための経済政策が不十分なままとなっている。

スケールの大きい研究とイノベーション政策をどのようにして社会的文脈の中に組み込み、かつパフォーマンス向上の条件を構築するのかを検証することが、いまや問題となっている。これまでに続いてきた諸計画と、それらの種々異なる諸目的を比較することは、どのようにして、この問題が位置づけられると同時に否認されてしまったのかについても私たちに教えてくれよう。ある意味で異なった研究とイノベーション政策を切り拓くことが本論考の目標となる。