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Creativity of Technology:
An Origin of Modernity?

Introduction

Technology studies are currently dominated by social constructivist approaches of many kinds: sociotechnical systems, social shaping, sociotechnical alignments, or actor-network approaches (see Grint and Woolgar 1997, chap. 1). Despite their differences, these approaches share a common stance against essentialist tendencies in one way or other. This characteristic can be found very clearly in the so-called social construction of technology (SCOT) approach (see Pinch and Bijker 1987 and Bijker 1995), as well as in the actor-network approach of Bruno Latour (1987, 1999) and Michel Callon (1995). Advocates of these approaches also argue against any determinism, whether it is a technological or a social determinism. That is, they do not presuppose a naive distinction between the "technical" and the "social." They maintain that technological development is not determined by technical or social factors. These approaches emphasize the unique, contingent situation in which a sociotechnical network is developed and in which technological artifacts are correspondingly interpreted. Technological artifacts and their ways of working are considered to have no inherent and essential attributes and are subject to "interpretative flexibility."

While this nonessentialism makes discussions in technology studies intriguing, it also makes them at times very complicated and difficult, especially when the relationship between modernity and technology is under analysis. It is difficult to retain a nonessentialist view of technology when we consider technology to be one of the essential factors of modernity; it seems that we cannot but assume that there is an essential character of modern technology that marks it as different from traditional technologies. In fact, we have many conceptual schemes that orient our thinking in an essentialist direction; for example, Heidegger's concept of "Gestell" or Horkhenner's concept of "the domination of instrumental rationality" (see Feenberg 1991).

The use of these concepts to formulate questions concerning modernity and technology tends to presuppose that modern technology is essentially different from traditional technology. However, when we analyze concrete technological phenomena and search for criteria that distinguish modern technologies from traditional ones, these concepts are too abstract to be helpful. On the other hand, the newer approaches in technology studies have so far ignored the question of modernity and technology. While proponents of a social constructivist approach analyze how technological artifacts and their ways of working are constituted through sociotechnical networks, they seldom make any attempt to differentiate modern technologies from premodern ones. Perhaps for them this problem seems burdened by too many metaphysical or ideological factors that presuppose the essentialist way of thinking. We thus find ourselves in a difficult position when we try to deal with the relationship between modernity and technology.

Is there a way to deal with this relationship without taking an essentialist stance? How can we distinguish modern technologies from traditional ones while taking interpretative flexibility seriously? These are the questions I wish to address in this chapter.

The following section addresses the creative character of technology, which is rarely discussed in traditional philosophy of technology. In this section I draw upon concepts developed and elaborated by Kitaro Nishida, a preeminent modern Japanese philosopher. His philosophy can be interpreted as an attempt to develop a nonessentialistic way of thinking. According to Nishida, the creativity of technological phenomena can be described as "reverse determination," (Nishida 1949b) which is realized spontaneously in each historical situation and sometimes against the original intent of the designers and producers.

In the second section, I discuss case studies of technology transfer in late nineteenth-century Japan to illustrate the creative character of technology and to exemplify the idea of reverse determination. In the concluding section I suggest, based on several accounts of modernization

in Japan, a characteristic that differentiates modern technologies from traditional ones. If we focus on the creative function of technology, we could describe the distinguishing feature of modern technology as the institutionalization of creativity within a certain sociotechnical network, in contrast to a traditional technology, in which creativity remains a random phenomenon.

1. "Otherness" and creativity of technology

1) The ambiguous character of technological artifacts

One of the important and most general reasons we create technologies is to free ourselves from various types of work. However, if we examine this familiar aspect of technology more closely, its ambiguous character becomes apparent.

According to cognitive theories of artifacts, artifacts are considered to be not only the result of intelligent human work but also the cause of intelligent behavior by human beings. In order to solve a problem, such as keeping out of the rain, we make an artifact, such as a roof. Once we have made the roof, we can entrust the work of problem solving (keeping the rain off our heads) to the roof without worrying again about how to solve that problem. Gregory calls this role of an artifact "potential intelligence" (Gregory 1981, p. 311ff).

From this cognitive view we can point out at least two features of artifacts and technology: (1) We use artifacts as instruments to solve certain problems. In this sense an artifact has a meaning only because human beings use it for a certain purpose. (2) But sometimes we are encouraged or compelled to use a specific means for a certain purpose, if we want to be intelligent and rational. Artifacts make our intelligent and rational behavior possible. In this way we can find in the most general characteristics of an instrument an ambiguous feature, which identifies a means as something more than a simple means.

I would like to call this surplus component-that which is "more than" a simple means-the "otherness" of technology, because it shows a component that cannot be reduced to a pure instrumental means and that sometimes motivates various interpretive activities corresponding to each situation. How can this ambiguous character be made clearer?

I think this problem is at the crux of the philosophy of technology. The kind of philosophy of technology we have depends on how we characterize this "otherness" of technology or on which facet of the "otherness" of technology we focus.

Gregory focuses on the positive and active roles of technological artifacts that inspire intelligent thought and rational action by human beings. Gregory puts this role of instrument into a historical order by saying "we are standing on our ancestor s shoulders" (Gregory 1981, p. 312). When we emphasize the contemporaneous function of the ancestor's accomplishment, utilized during the process of problem solving, we could also say that artifacts play a role of "co-actor" in our intelligent and rational behavior. This co-actor role of artifacts has been focused on and impressively described in actor-network theory (Latour 1992, 1999; Pickering 1995). According to their symmetry thesis, that is between humans and nonhumans, artifacts are regarded as hybrid actors or a material agency and play a fundamental role in constituting society. When we think about an artifact in our society, we can never neglect its actor element. In this sense the instrumental and co-actor roles of artifacts are inseparable and they must be considered to be two faces of one coin.

Surely it is important to characterize technological artifacts as co-actors, and surely it is important to see that the intelligence and rationality of human beings depends upon what kind of co-actors we have. It is especially important when we consider how to avoid designing inhuman environments and how to design "things that make us smart" (Norman 1993). On the other hand, it is also important to be aware that this active role of artifacts is only one element of the "otherness" of technology. In this perspective, artifacts are regarded as actors that function only according to the intention of the original designer, and there seems to remain no room for interpretative flexibility, which can be exercised in the interactive process between users and artifacts. In this sense, when we overemphasize this aspect of co-actor, there is a danger that we will adopt a perspective that is too rational and sometimes too deterministic concerning the relationship between human beings and technology.

For example, in principle it is possible not to use a roof in everyday life. But once a roof is made and widely used, it will be regarded as unintelligent, irrational, or even unhuman not to use it. Especially when artifacts are designed to be convenient and easy to use, this way of seeing them becomes unavoidable. However, exactly this character of artifacts (i.e., that artifacts determine the rational path of human action) constitutes the central core of theories embracing technological determinism. In this way, we can find a common ground between an instrumentalist view or a co-actor view and a deterministic view in which interpretative flexibility is neither sufficiently focused on nor highly prized. In either view, once the production process is finished, the artifact becomes a "black box" no longer open to various interpretations.

2) Creativity of technology

We are frequently encouraged or even compelled to use a particular artifact in a particular way in order to solve a problem when we want to be rational beings. However, sometimes the situation is far from being well defined and is ambiguous enough that there is an opportunity to develop a new relationship between human beings and artifacts. For example, a hammer can be used not only to build a house but also as a murder weapon, a paper weight, or even an objet d'art (Ihde 1999, p. 46). Although this case seems to be a little extreme, every artifact has this kind of multidimensionality in some way or other, and the history of technology is full of cases of this kind.

In fact, in the history of technology it sometimes happens that invented artifacts bring us a new end-means relation in which problems and artifacts are reinterpreted and redefined for purposes far removed from the intent of the original designer. The Internet is a good example. Although originally designed for military use, it has now become a new form of communication in our everyday lives (see Edwards 2003). Automobiles are another example. Before automobiles were invented, produced, and widely used, there was no urgent need to travel down a road faster than the speed of a horse or a horse-drawn carriage. In the beginning of the twentieth century, cars were not welcomed in the rural areas of America. They were called "devil wagons" and met a hostile reception from farmers (Kline and Pinch 1996). However, after automobiles became popular, traveling at the pace of a horse-drawn carriage became a "problem." In this sense new artifacts can be seen not only as problem solvers but also as "problem makers."

In addition to these cases, we can also find historical cases in which technological products are interpreted "negatively," contrary to the original intents of designers. Edward Tenner discusses various cases of this kind. Contrary to the prediction that making paper copies will become unnecessary because of electronic networking, offices are still full of paper. In another case, introducing cheaper security systems in a certain area caused malfunctions and user errors, which decreased the level of security. "Things seemed to be fighting back" (Tenner 1996, p. ix).

These cases impressively demonstrate the "otherness" of technology, which cannot be reduced to either a simple instrumental role or a co-actor role. This feature could be called the creativity of technology, because a new meaning for artifacts is realized, whether the new meaning is interpreted positively or negatively. What is characteristic in these cases is that the creativity is realized not in the design and production process, but rather in the interactive process between users and artifacts.

When it comes to the creative character of technology, we are often inclined to think mainly about the process of invention, design, innovation, and production, and not about users' reactions. Schumpeter (1961, chapter 2; 1950, chapter 7) emphasized the role of entrepreneurs in transforming technological changes into dramatic "innovations," resulting in economic development. Even social constructivists have tended to focus on the design and innovation process, in contrast to the process of diffusion to users. It is only recently that a designer-user distinction has been criticized along nonessentialist lines and the constructive role of users in finding creative new uses for artifacts designed for other purposes has been brought into focus (Fischer 1992; Kline and Pinch 1996; Kline 2000).

In order to clarify this creative role of the interaction between users and artifacts and also between producers and users, I would like to discuss Kitaro Nishida's philosophy, since his writings foreshadow the creative character of this interactive process.

3) Nishida's philosophy of technology

Nishida emphasizes the creative character of our historical world and our experience of it. He describes the creative process of our historical world with the phrase "from that which is made to that which makes" ("*tsukuraretamono kara tsukurumono e*"):

> Our concrete real world is a world which is a self-contradictory identity of one and many and moves from that which is made to that which makes. That means, our concrete real world is a historical world.
> "From that which is made to that which makes" means being productive. The historical world is the world of biological lives. But in the world of biological lives there is no process of production. There is no process "from that which is made to that which makes." In that world that which is made cannot be isolated from the subject. That which is made does not become an objective reality. The process is not that of active intuition.
> There is no reverse determination there. It is not yet a world of true concrete contradictory self-identity. (Nishida 1949b, p. 110.)

According to Nishida, our real world has a feature that must be described with contradictory concepts, such as subject and object, one and many, or motion and rest. Because our world always has contradictory characteristics, it cannot be stable; it moves incessantly and is always in a transformational process. This transformational process cannot be characterized as mechanical or teleological because it is not determined causally or planned or produced purposely, but arises spontaneously through the interaction of subject and object, of one and many. The process is creative because a new situation is always incommensurable with the old one from which it was formed. Because of this transformational character, Nishida calls our world "historical" and also "technological." Our world is technological because it is a world of poiesis, a self-formative act that moves from the created to the creating.

This transformation is an interaction in which subject and object are inseparably connected but at the same time strictly differentiated. For animals, the interaction is teleologically determined and not as contradictory as for human beings. In the case of human beings, the interaction is creative because the process has contradictory elements. The self and the environment are so contradictory that the self is newly determined and produced complementarily by the object that the self makes, and through it the self is brought to a new dimension. Cognition in this process is called "active intuition" because the subject is not a passive observer or a detached theoretician, but commits himself or herself to and is co-constructed with an object. This cognition can be found in our daily experiences, or in the cognitive skills of artisans, artists, or experimental scientists.

Although Nishida himself did not develop the philosophy of technology in the strict sense of the word, I think we can develop his theses and apply them to concrete technological phenomena. Provisionally we can point out the following three features.

1. Nishida emphasized that the technological process does not end when the technological artifacts are produced and handed to users. When the products have left the hands of producers and become independent from them, they have a chance to acquire a new meaning and a new developmental direction through their interaction with users. In this sense, Nishida's view of technology is one in which interpretative flexibility can be found not only in the processes of design and production but also in diffusion and use. Nishida describes this creative process as "reverse determination." Perhaps this concept suggests that users instead of producers determine the creative process. But what Nishida emphasizes is that neither producers nor users alone have a decisive role in determining technological developments. Indeed, a creative process is possible only through an interaction between producers and users, both of whom stand in a contradictory relation. In this sense Nishida's philosophy of technology can be interpreted as a radical form of nonessentialism.

2. Concerning technology, Nishida does not emphasize its familiar instrumental role, by which our life is made convenient and stable; instead, he underscores the role of technology in radically transforming our historical world. According to him, because of this characteristic of technology, our life is always in the process of self-negating or self-creating and is therefore unstable. "Even in the simple process of building a house, things are not given only as material but as something which has a fateful significance for our action. In every action we stand on the brink of crisis in some way or other. Our world of everyday life is a world of true crisis" (Nishida 1949a, p. 70).

3. Nishida finds this self-negating creative structure in various levels of the historical world. Especially in his later years, he tried to define the dynamic and critical structure of the world in the twentieth century. In a problematical essay written during World War II, he used the concept of "contradictory identity" to characterize the modern and global structure of the twentieth-century world in contrast to the eighteenth-century world. According to him, while nations and people in the eighteenth century were relatively independent and the concept of the world remained abstract, in the twentieth century the connections and the antagonisms among nations and people are so strengthened in a unified world that every nation is forced to transcend itself to fulfill its "world historical mission." "Today, as a result of scientific, technological and economic development, all nations and peoples have entered into one compact global space. Solving this problem lies in no way other than for each nation to awaken to its world-historical mission and for each to transcend itself while remaining thoroughly true to itself, and construct one 'multi-world' ('*sekaiteki sekai*')" (Nishida 1950, p. 428). Although his description of the modern world remains abstract and problematical because of its political implications, it is certain that Nishida tried to characterize the modernity of the historical world with his idiosyncratic conceptual scheme (Feenberg 2003).

Our next task is to explore the usefulness and the scope of Nishida's theses in the context of discussions concerning technology and modernity. How can we develop his abstract insights to solve the problems formulated earlier: dealing with the relationship between technology and modernity without taking an essentialist stance, and distinguishing modern technologies from traditional ones while taking interpretative flexibility seriously? In order to address this task, I would like to take up historical cases in which the relationship between technology and modernity became a central problem. The following cases relate primarily to the modernization of Japan, but I would like to compare this process with other technology transfer processes in different historical contexts. Through such a comparison it will become clear that western technology is "interpreted" and "translated" in different ways that correspond to different historical contexts. These are exactly the ways in which various types of interpretative flexibility and in this sense various "hermeneutical" experiences in the interaction of users and artifacts are realized.

2. *Hermeneutics of technology: modernization of Japan*

1) Radical transformation

a. Impact of civilization

In 1853 and 1854, the American Commodore Matthew C. Perry visited Japan on warships powered by steam engines; in their wake, as it were, a once-isolated Japan was opened to commerce with the western world. The Japanese called these warships "*kurobune*" (*black ships*), because they were painted black and raised a dense cloud of black smoke. These powerful technological machines greatly impressed the Japanese people, who began to recognize, although reluctantly, the necessity of cultural and technological exchange. Among the presents from the U.S. president to the shogun, the magnetic telegraph and a one-quarter-scale model of a locomotive engine especially stimulated curiosity in Japan. However, it was the ships' 10-inch cannons that became the center of attention among Japanese officials, who fully understood the urgent need for introducing modern weapons in Japan to prevent a third or fourth visit from Perry or other unwelcome visitors. In fact, every effort to introduce and develop modern weapons was made in the last days of the Edo period by the Tokugawa shogunate and various feudal domains as well as after the Meiji restoration (1868) by the new central government.

One of the main characteristics of the modernization of Japan in the late nineteenth century was that the Japanese quickly understood that in order to adopt modern western weapons, it was necessary to introduce various industries connected with military technology. In order to build and sustain those industries it would also be necessary to adopt the western civilization that formed the background for those industries.

Even before the Meiji restoration, many samurai visited western countries (illegally at first and then legally) and were greatly impressed by the western world. Immediately after opening Japan to exchange with foreign countries, the shogunate began to send various people to America and Europe to study abroad and to negotiate treaties of commerce. In 1871, after the Restoration, a large mission was sent to America and Europe. The members of this mission consisted of 47 primary officials of the new Meiji government. They spent more than 22 months examining political, social, economic, and technological circumstances in

developed countries. The result of these observations was summed up in the famous political slogans of the new government: "Promoting enterprise and developing products" ("*Shokusan Kougyou*") and "Enrich the country, strengthen the army" ("*Fukoku Kyouhei*"). In 1874, Ohkubo, the minister of home affairs, summarized the outlook of the new government: "The strength of the country depends on the wealth of people and the wealth of people depends on the amount of products. And while the amount of products depends upon whether people develop industry or not, its origin lies on whether the government leads and encourages the development" (Ohkubo 1988/1874, p. 16).

These statements have been interpreted to mean that the highest purpose was in the (military) strength of the country, and in order to realize this purpose, the development of industrial technology was indispensable. Certainly this meaning was included in the sentence. But if understood in this way, the development of industry and technology can be regarded as only one means among others, and it is not clear why the Japanese wished to introduce the entire western civilization together with many kinds of technology so hastily. This consideration brings us to a slightly different interpretation.

I think the emphasis lay not on the military strength of the country but rather on the development of industry, so that it was understood in the following way: for the time being, the development of industry and technology was most important, because only through them could the wealth and strength of the country be realized. If we interpret the statement in this way, it clearly expresses an ideology of technological determinism, in that the development of industrial technology makes possible the wealth and strength of a country. This was exactly the response of the Japanese people to the challenges of western modern civilization. They fully understood that the engine of western modernity was industrial technology; from their viewpoint, technology and modernity were inseparable. How could the Japanese people have acquired such a point of view? In order to understand, we should look at how they arrived at this insight.

b. Technology as instrument and demonstration of civilization

Stimulated by a telegraph demonstrated by Perry's crew, the Japanese began to introduce telegraph machines from various European countries, to learn this technology for themselves, and to make their own machines. As early as 1870, a public telegraph service began between Tokyo and Yokohama. Railroad service with locomotive engines began between these two cities two years later.

The rapid speed with which telegraph and railroad services were introduced was not in response to an urgent demand for them. Indeed, there was opposition to their hasty introduction because social and economic conditions in Japan were insufficient to support them, and in fact their economic results were disappointing. The many transplanted technologies, such as railways, telegraphs, shipbuilding, and iron manufacturing constituted a program of "industrialization from above" introduced by initiatives from the ministry of engineering.

Even if the process was an "industrialization from above," it did not meet a strong rejection from the grassroots or common people. Most of the people accepted and even welcomed with enthusiasm the modernization brought by these various technologies. In this context, I would like to focus on the demonstrative character of technological artifacts.

Although modern transplanted technologies such as steam locomotives and railway systems did not always function successfully in the sense of instrumental rationality, they had a great expressive meaning as a demonstration of western civilization in the early Meiji era. Tetsurou Nakaoka, a historian of technology, describes this characteristic of technology in the following way:

> Enterprises of industrialization in the early Meiji era proved to be not directly useful for the industrialization per se. In a sense they could be considered to be a waste. But what I want to say is that they have played a significant role for the industrialization in reproducing the "impact of civilization" in the mind of people, although this role was indirect. Only when we take this role into consideration, can we understand why grassroots people have shown such an extraordinary active response to the industrialization. Through the understanding of this role, we can also come to understand what an important role exhibitions have played in the Meiji era. (Nakaoka 1999, p. 165.)

In fact, during the Meiji era domestic industrial expositions were held regularly, and when the fifth exposition was held in Osaka in 1903, more

than four million people visited it. This fact alone shows how much interest people had in modern technologies. Modern technical artifacts introduced into sociotechnical networks that were already present played not only an instrumental role but also an expressive role. A train pulled by steam locomotives could be viewed as a running advertisement for modern western civilization; people could see the modern western world "through" a train.

The situation was not radically different later in the twentieth century. After the bitter defeat of Japan in World War II, cars imported from America symbolized western civilization in Japan. Cars were seen as an artifact embodying the American dream, and their acquisition and use symbolized the acquisition of a most advanced civilization. Modern technology was never considered to be a neutral instrument in modern Japan, from grassroots people to government officials. Rather, it has been considered something that is always value laden and cannot be detached from its original sociotechnical network.

c. Contrast between Japan and China

However, there is a famous proverb, "Japanese spirit and Western technology" ("*Wakon yousai*"), that seemingly contradicts this view. According to this proverb, western technology can be detached from its original context and introduced without changing Japanese culture. Sometimes the proverb is interpreted to show the real characteristics of the modernization process of Japan, and sometimes to explain its "success." While some intellectuals in the Edo and the early Meiji era emphasized the necessity of this thesis in order to introduce western science and technology without conflict, others criticized the one-sidedness and distortion of the "success" of the modernization process in Japan. On the assumption that the Japanese successfully introduced and developed science and technology detached from their original contexts, Steve Fuller has recently maintained that their success demonstrates that the "uniqueness" of western science is only a matter of contingency. According to Fuller, "the Japanese were bemused that modern Europeans could believe in such a superstitious sense of [Eurocentric] historical destiny" (Fuller 1997, p. 127).

Considering science at the time, that assertion has limited validity. During the nineteenth century, science experienced a "second revolution," became more institutionalized, and the connection between science and technology strengthened. But this does not mean that science became separable from its context, but rather that science was embedded more fully in its sociotechnical network. In this sense it became even more difficult to separate science from its context.

The proverb "Japanese spirit and Western technology" actually originated in China, where the Chinese followed more faithfully the thesis of adopting western technology but not western culture. However, the result was disastrous for them, at least at the end of the nineteenth century. Barton Hacker describes the contrast between the Chinese and the Japanese responses to Western technology:

> The crucial issue, and the point from which Chinese and Japanese response sharply diverged in the 1860s and later, was how much of Western culture was attached to the hardware. China and Japan found different answers…
> In a deeper sense, China's defeat [in the Sino-Japanese War of 1894-95] was rooted in a fundamental miscalculation. Self-strengthening assumed that China could defend its traditional society against the West with Western weapons, that the West's military technology could be detached from Western culture as a whole…
> The Meiji Restoration of 1868 was so named from the presumed return to the emperor of his former power, usurped in recent centuries by the shogun. The rhetoric of imperial rule and a return to time-honored forms disguised far-reaching changes. Younger samurai had played key roles in toppling the Tokugawa regime. Deeply impressed by the West's military technology, they assumed their new government posts determined to sustain Japan's independence with Western weapons. But they accepted, as their Chinese counterparts did not, the price of that technology, which involved not only a complete revamping of the military system but also large-scale industrialization and all it implied. (Hacker 1997, pp. 283-286.)

An important point is that the whole scale of modernization was not regarded as a necessary price by most Japanese people but welcomed by them. Perhaps the proverb "Japanese spirit, Western technology" also played a certain role in Japan. But if we think it did, its function must be considered to belong to an ideological dimension. If we pretend to believe it, it is possible to develop a radical cultural change under the guise of this ideology, avoiding, or at least decreasing the conflict between traditional culture and modern technology. While in the ideological dimension the thesis that technology is a neutral instrument played a certain role, in the material dimension everything was changed, continuously responding to and accepting the modern technology.

2) Radical translation

The story about the hermeneutical process of modernization in Japan is not yet complete. In order to highlight the characteristics of this process, I would like to go back to another type of encounter that took place a few centuries before the above-mentioned story.

a. Medieval and early modern age of Europe

"The clock, not the steam-engine, is the key machine of the modern industrial age" (Mumford 1934, p. 14). This famous statement by Lewis Mumford identifies the clock as the icon of modern machinery. Mumford did not tell a deterministic story concerning the relationship between technology and modernity. Rather, he emphasized social factors, such as the discipline and regularity of the monastic life, which constituted the background of the invention and diffusion of mechanical clocks.

Recently historians have suggested that we should not overemphasize the mechanistic image of the monastery and that Mumford's thesis has only limited validity. Certainly it is misleading to talk about the machine-like rhythm of monastic life because "life according to the Rule was bound in a very high degree to natural time givers, daylight and the seasons, and was by no means marked by ascetic resistance to the natural environment" (Dohrn-van Rossum 1996, p. 38). Although the Christian church played an important role in the growth of interest in time measurement and timekeeping, and also in the development of mechanical clocks, it was only one factor among others. The new source of demand for mechanical clocks came from "the numerous courts-royal, princely, ducal, and episcopal" and "the rapidly growing urban centers with their active, ambitious bourgeois patriciates" (Landes 1983, p. 70).

I wish here to emphasize the role of clocks that is essentially connected with technical functions but includes more than these. For a long time, clocks have been used as a metaphor for the mechanical worldview. We find this even in the early history of clocks. "It is in the works of the great ecclesiastic and mathematician Nicholas Oresmus, who died in 1382 as Bishop of Lisieux, that we first find the metaphor of the universe as a vast mechanical clock created and set running by God so that 'all the wheels move as harmoniously as possible.' It was a notion with a future: eventually the metaphor became a metaphysics" (White 1962, p. 125).

During the change from the medieval to the modern age, clocks influenced (and were influenced by) dynamic changes in sociotechnical networks. But more than that, clocks also played a decisive role in the radical change of the worldview. We could describe this as a creative role of technology, although it does not have a direct relation to certain technological innovations. What is different in the case of clocks is that clocks had no strong social or technological networks by which their creative function could be transferred and realized, so that they were "interpreted" in radically different ways. We can clarify this point by contrasting the introduction of western mechanical clocks into China and Japan, which began in the late sixteenth and early seventeenth centuries.

b. China

In the seventeenth century, many Christian missionaries from Spain or France visited China to propagate their faith, and in the eighteenth century, many Europeans rushed to establish commercial ties with China, to meet the soaring demand in western markets for China's silk, porcelain, and especially tea. This cultural and commercial exchange between China and Europe remained unbalanced or even one-sided for a long time because the Chinese found nothing interesting in what Europeans brought, while Europeans wanted to import various things from China.

One of few things in which people in China expressed an interest was the mechanical clock. Chinese emperors showed great interest in mechanical things and collected many kinds of western clocks. Father Valentin wrote in the 1730s, "The Imperial palace is stuffed with clocks, …watches, carillons, repeaters, organs, spheres, and astronomical clocks of all kinds and descriptions—there are more than four thousand pieces from the best masters of Paris and London, very many of which I have had through my hands for repair or cleaning" (Landes 1983, p. 42; Tsunoyama 1984, p. 42). Clocks were displayed together with pictures, porcelains, pottery, and many kinds of playthings in palaces and enjoyed by people in court. There was even a factory in which clocks were made and repaired by artisans, instructed by Christian fathers who were specialists in the technology. In spite of this interest in mechanical clocks, the Chinese did not use them as an instrument for time measurement and timekeeping.

Why didn't the Chinese use mechanical clocks in their everyday life? Why did they not develop the technology of mechanical clocks when in the tenth century they had invented a splendid mechanical device that expressed astronomical movement and was used for measuring time? The simplest answer would be "because they were useless in a society in which timekeeping had no decisive role." A more insightful answer would be the following: While the Jesuits wished to persuade the Chinese people that a civilization that could produce a manifestly superior science and technology must be superior in other respects, especially in the spiritual realm, the Chinese had seen a dangerous element embodied in the European mechanical clock, which made an assault on China's self-esteem and could not be reduced to a neutral instrument. The Chinese people were deeply disappointed by the western worldview, in which China was located not in the center but only in a small and peripheral part of the world. In this sense, we could interpret the response of the Chinese to western clocks as a deliberate rejection (Landes 1983, pp. 44-47). In any case, until the middle of the nineteenth century, clocks were considered mainly to be interior decoration or play-things for emperors and high officials.

If we say that aesthetic meaning is not the main function of a clock and the use of a clock as an objet d'art is irrational, we presuppose what the main purpose is and what the side effects are. However, this distinction between purpose and side effect is always constructed in a cultural context, and side effects are well known to sometimes play a creative role in the development of technology. When we remember the windmill in the medieval age, the interpretation of clocks as aesthetic rather than functional objects in seventeenth- and eighteenth-century China could be recognized as a typical case of a hermeneutical experience concerning technological artifacts. According to Lynn White, "In Tibet windmills are used only thus, in the technology of prayer; in China they are applied solely to pumping or to hauling canal boats over lock-sides, but not for grinding grain; in Afghanistan they are engaged chiefly in milling flour" (White 1962, p. 86).

c. Japan

During the same period, very few western clocks were imported into Japan. Japan used a variable-hour time system so Japanese artisans adapted newly introduced western clock mechanisms to move according to the Japanese time system. In adapting the original mechanisms, the artisans invented complex mechanisms of their own to correspond to the complexities of the Japanese time system, in which daytime hours were longer than nighttime hours in summer and shorter in winter. "Some clocks had several interchangeable face plates with different spaces between the markings for the hours. On others there were sliding weights which had to be adjusted manually at sunrise and sunset to slow down or speed up the working of the mechanism. Others again had a double verge-and-foliot system which marked and measured the elusive flow of tune" (Morris-Suzuki 1994, p. 52). In effect, Japanese artisans developed many original types of clocks.

The development of these "traditional Japanese clocks" (*wadokei*) can be seen as unique and original in the history of clocks, but as soon as the western time system was introduced after the Meiji Restoration, these clocks became useless, abandoned, and forgotten. Sometimes the Japanese pattern of clock development, adapting western technology to a Japanese time system, is considered to be a degeneration of technology.

However, there is no need to regard this adaptive process as degenerative and the western way as progressive. Rather, one could view traditional Japanese clocks as successful accomplishments of instrumental rationality, which supports the thesis of social constructivism of technology. Japanese artisans opened the black box of a western clock mechanism and redesigned it to correspond to the needs of Japanese social groups. In this way they showed the interpretative flexibility of technology across different cultures.

Thus we can find three types of interpretations of clocks. In the first case, clocks were interpreted as something *more* than technical; in the second as something *other* than technical; and in the third as something *simply* technical. In this sense, the Japanese reaction could be considered to be the most rational and enlightened on technological grounds in the narrow sense of the word.

In contrast to Japan, in Europe clocks were seen as embodying a metaphysical meaning, and people did not perceive clocks alone but perceived the world "through" clocks (Ihde 1990, p. 61). Here we can find a similar relationship between the artifacts and the meaning embodied in them, as in the case of the introduction of modern technology into Japan in the late nineteenth century. In both cases, modern technology was not regarded as merely a neutral instrument, but as something more. It is not the case that because modern machines are considered to be useful in a pregiven society, they are introduced into it. Rather it is because they attract people as something more than a simple instrument that they are introduced and accepted as a useful instrument. The meaning embodied in artifacts varies and depends on historical situations. In any case, modern characteristics of artifacts cannot be reduced to their instrumental or co-actor role, and they cannot be fully understood without taking their surplus component into consideration, which is what motivates people to accept them, whether it belongs to a metaphysical or an ideological dimension.

Why did the Japanese show such an enthusiasm for western technologies in the late nineteenth century, while they were so "rational" about western clocks earlier? In other words, why did the surplus component embodied in modern machines in the late nineteenth century not remain in the ideological dimension, but in fact have a material influence on Japanese society? Why weren't modern machines detached from their (western) sociotechnical network, as in the case of the clocks in the seventeenth or eighteenth century? Certainly there were many reasons that must be clarified through empirical studies. But in order to find an answer to this question, I would like to go back again to the modernization of Japan.

3) Mediated transformation: continuity and discontinuity

The Japanese cases demonstrate contrasting types of technology transfer between cultures. In the case of clocks in the seventeenth and eighteenth century, the new artifacts (western clocks) underwent a radical translation, as Japanese artisans developed an efficient instrumental rationality to fit them into a traditional network. In contrast, the encounter between modern technology and the Japanese in the late nineteenth century produced a radical transformation of the sociotechnical network, and as we have seen, the conception of technological determinism accompanying this transformation was the result of the interpretative activities of Japanese people. Despite the striking contrast, there is an interesting relation in the two types of technology transfer. In order to clarify it, I would like to follow the story of the artisans who developed Japanese traditional clocks.

The artisans who developed and produced a Japanese style of clock were closely connected to another innovation in the Tokugawa Edo period: the automaton (*karakuri*). The introduction of clockwork provided the opportunity to make a more realistic representation of human behavior possible. One of the most famous artisans in this technological tradition was Hisashige Tanaka (1799-1881), who built a very impressive astronomical instrument in the Edo period. Immediately after the arrival of Commodore Perry's fleet of ships, Saga Domain invited Tanaka to advise on technological modernization of steam engines of ships and guns, among other things. In 1875 Tanaka established a private machine-making firm, which later became part of the twentieth-century manufacturing giant Toshiba (Morris-Suzuki 1994, p. 53).

The connection between Japanese clocks, automatons, and advanced technology was not direct, but was rather complicated. The gap between traditional Japanese technology and more advanced western technology was huge at the time. In the iron or railroad industries, for example, almost every machine part was imported during the early adoption phase in Japan, and many foreign engineers and artisans (*Oyatoi gaikokujin*, literally "hired foreigners") were invited to build factories and teach and advise Japanese engineers and artisans. However, few of the transferred technologies took root easily in the new context; only after Japanese engineers and artisans worked hard to translate those technologies into local terms did they function successfully in the Japanese context. In this sense we must confirm that the rapid and radical transformation of the Japanese technological network depended on the support work of Japanese technicians. This was a decisive point in the modernization of Japan, as it is in many other cases: skilled artisans and domestic engineers played a critical role. I would like to especially emphasize the role of *traditional* artisans in adapting the new technology to the environment and preparing a suitable environment for the new technology. While machines and factory systems introduced during the industrial revolution are often thought of as deskilling laborers and leading to the

disappearance of traditional artisans, many economic historians emphasize the important role of artisans in the innovation and development of industrial technology.

As for the role of artisans and skilled workers in the process of industrial revolution and the modernization of industry, there continues a debate (Sabel and Zeitlin 1985, 1997; Odaka 1993). The concept of artisans itself is sometimes ambiguous, and the situation around artisans and skilled workers is different in different countries and dependent on historical conditions. But at least in the case of Japan, almost all historians seem to agree that traditional artisans played an important role in the early phase of the industrial revolution in Japan.

According to Rosenberg (1970), for example, a capital goods industry plays an important role in the development and transfer of a technology, by creating an appropriate environment for repair and maintenance and successful performance of the machines. Rosenberg also emphasizes the aspects of technology that are incorporated by skilled personnel and are not explicitly codified. The transfer of these people played a decisive role in the process of technology transfer in many kinds of machine-making industry in the nineteenth century.

> But in making new products and processes practicable, there is a long adjustment process during which the invention is improved, bugs ironed out, the technique modified to suit the specific needs of users, and the "tooling up" and numerous adaptations made so that the new product (process) can not only be produced but can be produced at low cost. The idea that an invention reaches a stage of commercial profitability first and is then "introduced" is, as a matter of fact, simple-minded. It is during a (frequently protracted) shakedown period in early introduction that it becomes obviously worthwhile to bother making the improvement. Improvements in the production of a new product occur during the commercial introduction.
> Alternatively put, there has been a tendency to think of a long pre-commercial period when an invention is treated as somehow shaped and modified by exogenous factors until it is ready for commercial introduction. This is not only unrealistic; it is a view which has also been responsible for the neglect of the critical role of capital goods firms in the innovation process. (Rosenberg 1970, p. 569.)

In the capital goods industry, various machines and parts for machines are invented, designed, and produced in order to solve problems that occur in the interactive process between producers and consumers. In this sense, the capital goods industry plays a necessary role in preparing an environment in which a new technology can be realized or transferred. We could also say that capital goods industries are an institutional foundation that constantly makes possible technological innovation and transfer by mediating between the producer of machines and their users.

We can find many parallels between the capital goods industries cited in Rosenberg's cases and the roles Japanese artisans played in the modernization process in Japan. Surprisingly, after the Restoration the central Japanese government took into consideration this role for skilled personnel. When the new government sent a mission of artisans and high officials to the international exhibition held in Vienna in 1873, several of them remained for two years after the exhibition to continue learning various technologies. Most of the technologies that they brought back were not directly connected to advanced technologies, but to traditional ones. These were more readily accepted and this allowed them to introduce new inventions and innovations very rapidly. In addition to the international exhibition, regularly held domestic exhibitions provided occasions for the rapid and wide exchange of information about new inventions and technical know-how (Nakaoka 1999, p. 169ff). In this case, exhibitions played a role in an instrumental dimension, rather than in an ideological or demonstrative dimension. Within the radical technological change in the realm of advanced technology, there was a relatively continuous and gradual transformation in the field of traditional technology.

Thus we find a material background for the rapid introduction of many types of Western technology in the late nineteenth century and a technological foundation for the enthusiastic response of Japanese people at that time. Without this, the ideology of modern civilization incorporated in various machines would have remained only an ideology. The ideology of technological determinism at the core of Ohkubo's proposal for the government to promote enterprise and industrialization would also have remained merely ideology. A number of historians of technology support this view of modernization in Japan.

Rosenberg indicates that the subcontract structure common in Japan contributed to the success of modern Japan. Traditional technology, constituting a lower level of this dual structure, played the role of a capital goods industry, making possible the interaction between producers (in this case, European advanced industry) and users (the Japanese industrial system). In addition, Rosenberg attributes many unsuccessful technology transfer projects to the absence of such appropriate conditions (Rosenberg 1970, pp. 565, 570).

Jun Suzuki indicates the importance of gun smithery, which remained at a certain developmental level during the Edo period. Guns were introduced into Japan in the mid-sixteenth century, adopted very quickly (with innovations), and used widely for the next 100 years. After the establishment of the Tokugawa Shogunate, there were few occasions when guns were used in war, but guns have been produced on a limited scale ever since. According to Suzuki, traditional gunsmiths played an important role in the effort to modernize guns and cannons in the last days of the Tokugawa shogunate, and after the Meiji Restoration these gunsmiths moved into manufacturing industries just as the clock-artisan Tanaka did (Suzuki 1996, chap. 1).

Konosuke Odaka indicates the difficulty that Japan would have had in promoting an iron and machine industry if there had been no skilled mechanics at the beginning phase of industrialization. "If there had not been these artisans and their tradition, the process of iron manufacturing and machine making would have remained a 'black box' for Japanese people, which could not be understood for a longer time and the domestication of this process would have proceeded (even if it should succeed) much more slowly" (Odaka 1993, pp. 239-240).

Tessa Morris-Suzuki emphasizes more clearly the role of the traditional technology developed before the Meiji Restoration and describes the course of development of industry and technology with the concept of a social network:

> The upheavals accompanying the transition from the Tokugawa political order to the centralized Meiji state resulted in reshaping of this network. The new system bore traces of its pre-Meiji heritage, but was at the same time distinctively different both in its structure and in its implicit objectives. In the first years of the Meiji era, the technological

> initiatives of local, grassroots groups were relatively far removed from the ambitious modernization schemes of the central state. While central government laid the foundations of a modern industrial infrastructure, with railways, telegraph and imported mining, factory, and military technologies, regional institutions encouraged incremental innovation and the incorporation of simple foreign techniques into existing production system. By the end of the century, however, center and periphery were beginning to be woven together into a multiple-layered hierarchy of connected institutions which proved an effective means of spreading technological information. (Morris-Suzuki 1994, pp. 103-104.)

The characteristics of modern technology are sometimes considered to be universal and context independent, in contrast to traditional technology, which is considered to be embedded in a local cultural context. However, without an environment provided by traditional technologies, modern technologies cannot be transferred and introduced into other contexts. In this sense, we could say that it is the developmental processes, mediated translation, and transformation processes of *traditional* technology that make the *modernity* of technology possible. Without support from traditional technologies, the ideological character of modern technology could not be transformed into reality. Modernity without the help of tradition would remain only an ideology.

Conclusions

What can we conclude from these stories about the modernization process in Japan? One of the most conspicuous characteristics of this process in Japan is the dual structure of its sociotechnical network, with an advanced sector of modern technology and a parallel domestic sector of traditional technology. The advanced sector functions as if transferred technology guides and determines the direction of modernization. In reality, however, the advanced sector interacts with the domestic sector, where traditional technology plays a role of instrumental rationality, decreasing the gap between the two sectors sufficiently that advanced technology is adapted to local circumstances. Through this interaction,

the scope of possibilities is restricted; the process is channeled in a certain direction; and rapid and continuous adaptation and development of technology becomes possible.

What made the modernization process in Japan possible were these seemingly contradictory yet inseparably connected technology sectors. If these factors had been too contradictory, there would have been no successful process, as was the case during an encounter between China and western civilization in the late nineteenth century. If they had not been contradictory enough, there would have been no radical transformation, as happened in the encounter between Japanese artisans and western clocks in the early seventeenth century. The encounter between the Chinese people and western clocks in the seventeenth and eighteenth century can be considered to belong to the latter kind of case because the two sectors remained indifferent and no contradiction developed between them. In this sense, the manner in which the creativity of technology is realized depends on each historical context; it is thoroughly contingent, and we cannot generalize the lessons of the Japanese experience. What we can say is that modernity does not exist in a universal sense, but in modernity there is always a dual structure of modern factors and traditional factors. In this sense there are always various modernities (in plural) together with various transformational processes of tradition.

On the other hand, we have developed a relatively general and formal structure of modern technology in which the capital goods industry plays a decisive role. In this structure, a capital goods industry is an environment in which the interaction between producer and user is constantly made possible and the "reverse determination" initiated by users can be realized. What about the role of artisans, which we have confirmed in the case of the early stage of the industrialization of Japan? Does the argument still hold concerning the later stage of industrialization? Even scholars who emphasize the role of skilled workers who made flexible industrialization possible, confirm that by the 1920s (by the 1960s in Japan) the dominance of mass production became irreversible and the role of artisans declined.

Surely artisanal skills have changed greatly and most traditional artisans disappeared by the middle of the twentieth century. Especially after computer-operated machine tools were introduced, many types of knowledge became obsolete and disappeared. However, we cannot neglect the fact that while old skills might disappear with the introduction of new machines, new skills become indispensable in adapting new machines to new circumstances. With advanced technologies, these translating and mediating roles are no longer filled by traditional artisans, but by engineers who have academic training. In spite of these circumstances, the knowledge necessary for accomplishing the work cannot be reduced to codified scientific knowledge, but still requires skill and intuition gained through experience, just as the knowledge of traditional artisans did (Ferguson 1992, chap. 2). Only through the application of this kind of knowledge by skilled people is flexible and rapid mediating work possible.

We find a similar structure in many twentieth-century technologies as well. Paul Rosen, for example, finds a flexible feature of technology in the development of mountain bikes in the United States and England since the 1970s (Rosen 1993). In contrast to the design of the standard bicycle, which has been mostly stable for the past hundred years, the design of mountain bikes has changed constantly since their invention.

> Stabilization in mountain bikes has occurred, at a certain level. The features that distinguish mountain bikes from road bikes […] continue to hold true. However, closer investigation of the technological details shows constant shifting in the design of frames and components, which means that since their inception, mountain bikes have been moving further and further away from being a stable artifact. They are in a constant and irresolvable state of interpretive flexibility. (Rosen 1993, p. 505.)

Rosen calls this type of industry post-Fordist and labels mountain bikes as "a technological artifact of postmodern society" (Rosen 1993, p. 494). This kind of continual innovation of mountain bikes has become possible because the base of production has been transferred and almost all components are produced in Taiwan. Taiwanese companies have the capacity to fulfill continually changing requirements from trading companies in England and the United States. These trading companies only assemble the imported components. In this sense, Taiwanese companies play the role of a capital goods industry.

In the history of many technologies there is a reciprocal interaction between producer and user on the one hand, and the capital goods technology that supports such an interaction on the other hand. Through

the processes supported by this institutional structure, new values and new problems are constantly created. This type of creation is held in high esteem in "our" modern society, while it was not in premodern traditional society If we can think in this way and include the concept of "postmodern" in the concept of "modern" in the broad sense of the word, we can arrive at a distinction between "traditional" and "modern" in the realm of technology.

This distinction, then, lies in the way in which creativity is realized differently in modern and traditional technologies. The creative process can be found in any course of technological development since the beginning of the history of human technology. What is distinctive in the modern age is that this process is not a random phenomenon, but is institutionalized in a sociotechnical network that has a particular dynamic in which technologies are continually transformed. Since the latter half of the nineteenth century the international connections between different countries and different cultures have strengthened, and the global character of the world has begun to become conspicuous. While capital goods industries support this global tendency by accelerating the interactions between producers and users in various fields, they are also supported and oriented by this tendency (Feenberg 2003). Different and heterogeneous parts of the sociotechnical network of the modern world are not indifferent to each other and are always involved in a contradictory, interactive process that occurs between them. In this way, the interaction between producers and users does not remain stable, but is always part of a transformational activity where, in the words of Nishida, "reverse determination" leads to conspicuously "creative" results.