Special Contribution
Business Innovation in IoT Era: Rebuilding Business Model for Monozukuri

Koichi Ogawa
Senior Researcher
Policy Alternatives Research Institute
The University of Tokyo

1. Industrial structure of global market has changed

Global industry has entered a historic, once-in-a-hundred-year period of dramatic change. The impact was initially limited to the digital and software-rich electronics industry during the 1990s, while from the 2010s on, dramatic changes began to appear in non-digital industries as well, reflecting a transformation of the global industrial structure. More recently, signs of this upheaval have begun to appear even in the automobile industry, marking an extension of this period into the Internet of Things (IoT) era.

One reason digital technology and software are changing the industrial structure is that product architecture is evolving towards a combination of technology modules. Another is that the interfaces and protocols interconnecting those modules are being defined by open standards, which enables an enterprise to enter a market by simply procuring and combining modules without knowing the technologies used in those components (that is, without having to accumulate technologies through basic research). A third reason is the accelerating speed at which technologies can cross borders and combine with other technologies.

The transformation of the industrial structure on the basis of personal computers, smartphones, and LCD televisions was reflected in the sudden appearance of an open business ecosystem across national borders, which enabled broad range collaboration.

As a result, the traditional vertical integration model, which used to be extremely stable, has lost its economic rationality, and the traditional business concept of capturing all added value within a single company is no longer valid. In the 2000s, the Japanese electronics industry encountered considerable hardships, which could be traced to this breakdown of the traditional business model. Fujitsu was no exception to this problem.

This inability to adapt to a large-scale transformation of the industrial structure and subsequent changes in rules governing competition was not limited to Japanese companies. It also befell IBM, which continued to embrace traditional business concepts into the latter half of the 1980s, as well as Siemens and Phillips in the mid-1990s. IBM, which had been unrivaled in brand power, technical competence, human resources, and selling power, was forced to lay off about 150,000 employees in the early 1990s.

<Arrival of IoT era>

The IoT will expand on a large scale in the 2020s, and at that time, we can expect the transformation of the industrial structure to take place in many other industries. The initial stage of IoT has been discussed on the premise that digital-type things will simply be connected over the network. However, the 2020s will see further innovation in LSI chip and sensor technologies, enabling LSI chips and sensors to be affixed, for example, to sporting goods, beverages, and food items and enabling services and people to be connected in a relatively easy manner. As services and things become interconnected, the IoT era will begin to manifest itself before our very eyes. It is said that chips costing from 10 to 30 US cents apiece are now being distributed in the Chinese market. The transformation of the industrial structure that began in the electronics industry in the 1990s is set to expand throughout the global market in the IoT era of the 2020s.

This transformation of the industrial structure will bring a great change to the way in which companies compete. In many industrial areas, the conventional strategy for winning is no longer viable. We cannot afford to repeat the same mistakes in the electronics industry. We must learn from the mistakes that Japanese electronics companies made and apply the knowledge gained to the IoT era.

Before discussing specific measures, I would like to take a look at the 18th and 19th centuries to provide some background to the present economic environment.

2. World Industry is in third economic revolution

Research in the field of economic history has revealed that the period extending from about 10,000 years ago (when our ancestors began to form settlements) to the 18th century was essentially one of minimal economic growth. The human population as well grew by only a small amount during this time. Then, in the latter half of the 18th century, the economy suddenly began to grow exponentially, accompanied by a sharp increase in population. This was the economic revolution that began in England. Many people call this an "industrial revolution," but considering that this revolution, in addition to improving productivity, also transformed the world economic system and completely changed the lives of many people, I call it an "economic revolution."

This first economic revolution that took place in England about 250 years ago was an "industrialization of the empirical rules" that humans had accumulated over several thousand years. Two typical examples are the steam engine and the mechanized textile plant. From the 14th century to the 18th century, productivity increased by several tens of percent at the most every 100 years, but the first economic revolution suddenly raised people's standard of living by as much as 20 times.

Then, about 150 years later, beginning in the 1870s, the second economic revolution began in Germany (Prussia) and the United States. The key features of this revolution were the acceleration of technological innovation through various combinations of the natural laws and the successive birth of new industries through various combinations of the technological innovations.

For example, basic technologies supported by scientific knowledge substantially improved the functionality and performance of steam engines and greatly reduced transportation costs, thereby transforming the industrial structure. In addition, the invention of power generation and supply/transmission technologies, incorporated, for example, in the electric motor and internal combustion engine, gave birth to the electronics and automobile industries. Needless to say, these technologies and inventions increased productivity and contributed to employment and economic growth.

Moreover, thanks to the derivation of chemical kinetics, the discovery of the benzene ring structure, etc. by chemists, this period also saw an accumulation of basic technologies for performing chemical synthesis, enabling the preparation by artificial means of aspirin and other drugs and diverse organic compounds. The chemical industry that today supports our advanced standard of living greatly evolved during this period. In a sense, the second economic revolution was an "industrialization by natural laws."

<What is the third economic revolution?>

The third economic revolution, the focus of this paper, differs from the first and second economic revolutions in the use of a software-mediated digital format in the design of products Software is developed using a programming language, i.e., an artificial logical system created by humans. Although we cannot change the natural laws, we are free to change this logical system as we please.

The combination of natural laws in new ways requires long term basic research and substantial funding, but software makes it possible to embody ideas and expectations as product functions as desired through creative programming. I thus define the third economic revolution as the "industrialization by logical systems."

The performance of microprocessors running software increased by 10 times at most in the 1970s, but this was followed by a 30-fold gain in the 1980s and a 100-fold improvement every 10 years from the 1990s on. This phenomenal technological innovation brought about the third economic revolution driven by software. It is said that this trend will continue for another 10 to 20 years.

Joseph Schumpeter defined innovation as the creation of new value by combining the means of production, resources, etc. within economic activities in new ways, different from the status quo (creative destruction).[1] However, in the 2020s, when all things, services, and even people will be interconnected via the network, it will be possible to create an unlimited number of new combinations in a far easier manner than in the world envisioned by Schumpeter. In addition, software will enable the rules governing mutual connections (interfaces) to be artificially determined through the use of open standards. As a result, new combinations will be formed much faster and on a larger scale than the combination of natural laws. From here on, heretofore unheard of value will be created in rapid succession by software.

The cloud economy that has been growing since the 2000s will expand this trend even further, and then large industries completely different in nature will come to be instantly connected, thereby creating new value. The IoT economic environment of the 2020s will be an extension of this trend, and in this environment, the global market will inevitably become a huge business ecosystem in which the rules of competition undergo a complete transformation. To put it another way, traditional management methods in many industrial fields will not function as easily as before. It is therefore important that we proactively attempt to predict this transformation in the rules of competition before they completely change. This is the background to why we must pursue business innovation.

3. Toward Monozukuri innovation

Japan and Europe have been troubled by a deflationary economy. A similar deflationary economy occurred in the 16th and 17th centuries in Genoa and Venice, which were then flourishing city-states and centers of finance. The same occurred in England in the 18th century and in Germany the late 19th century. It was the industrial revolution, that is, the economic revolution that brought a definitive end to the long-term stagnation and triggered an era of economic growth through innovative technologies and products. The financial economy has been in existence on a large scale since the Age of Discovery in the 16th century, but its role in guiding gains in productivity has been overlooked. Although it is always innovation in technologies and products that plays a leading role, it is finance that works behind the scenes to support the commercialization of that innovation.

Thomas Piketty asserted that the rate of return on capital has always been greater than the rate of economic growth, resulting in economic inequality,[2] but much innovation has taken place in deflationary times, that is, at times in which the rate of return on capital was extremely low. Innovation in technologies and products has given birth to a large middle class and reduced income disparities while stabilizing capitalism and providing a foundation for democracy.

On entering the 2010s, Japan, the United States, and Europe have tried to support unstable economies through monetary policies, but the economic stimulus was temporary. To rescue economies from deflation and put them on a path to growth, innovation is needed in technologies and products that can provide fundamental support for the industrial economy. Increases in industrial productivity through innovation are needed to put economies on a sustainable growth path.

<Business innovation based on CPS has become a necessity>

The conventional approach relied solely on the hardware technologies that have continued to evolve since the second economic revolution and is not what we should address for the coming IoT economy. Rather, added value will be created on the basis of the cyber-physical system (CPS) that interlinks the physical world (hardware-centric) and cyberspace (software-centric). It is thus essential that a mechanism be constructed for leveraging the power of software to double or even triple added value. At the same time, a mechanism must be constructed for maintaining and expanding this added value within a global business ecosystem.[3]

The basic structure of a business ecosystem in the IoT era is shown in **Figure 1**, and the total CPS structure is shown in **Figure 2**. In the 2020s, when companies will be interconnected across borders, a single company will be unable to cover all of the areas shown in Figure 1. This business ecosystem requires that companies specialize in at least one area, i.e., their core competence as reflected in their business platform (BP). Therefore, an open-close strategy for closing the core area and opening a non-core area is necessary. In short, companies must transition from full-set type vertical integration to ecosystem-based vertical integration.

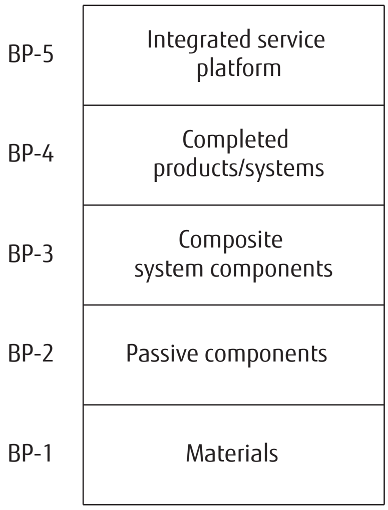

Figure 1
Business platform (BP) structure of business ecosystem in IoT era.

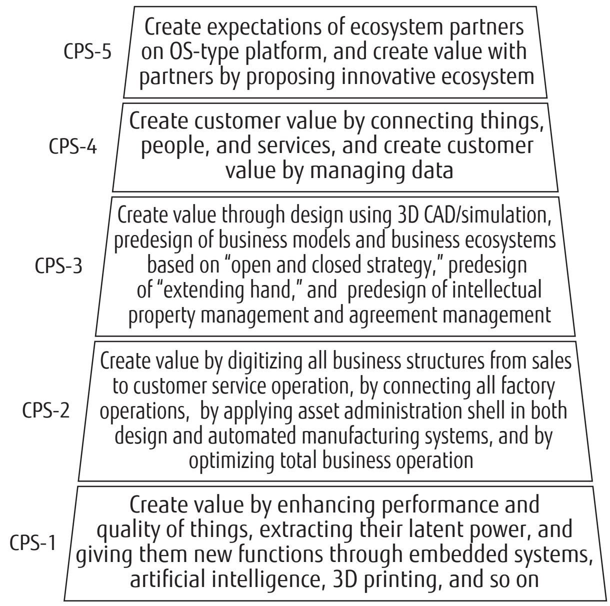

Figure 2
Total cyber-physical system (CPS) structure.

The business model for creating added value is different for each of the platforms. One or several of the CPS design concepts shown in Figure 2 must be chosen to maximize added value in each platform in the IoT era. This is why the central theme of this paper lies in the CPS structure.

For example, a business-model design based on CPS-1 is necessary for BP-1. Many models for creating added value have been refined by Japanese Monozukuri companies (Monozukuri is the Japanese way of manufacturing); models for embedded software-controlled geomagnetic sensors and embedded software-controlled secondary batteries are good examples.

Japanese Monozukuri companies have superior abilities for BP-1, but it was European and American companies that evolved CPS-1 in BP-2 and BP-3 to maximize added value. In more recent years, the CPS-2 design concept, which makes use of an asset management shell, has been introduced in BP-2 and BP-3 by German companies. In this way, techniques for creating new value have been evolving to the point that an open-close strategy for a business model can be predesigned in cyberspace.

The CPS-2 design concept can also be quite effective in designing new value in BP-4. It has been incorporated in many systems, including Boeing's aircraft design system, Volkswagen's Modular Transverse Matrix (MQB) platform, Toyota New Global Architecture (TNGA), Nissan's Common Module Family (CMF), Apple's iPhone, and Fujitsu virtual Monozukuri.

In any case, what is common to all of these examples is the concept of the open-close strategy for forming an "extending hand" to control the market from one's own core area (closed) to an ecosystem area (open).

Typical of BP-5 are service platforms supporting a company's business. On entering the 2010s, several companies began to roll out large-scale, integrated platforms in the global market. Typical examples are General Electric's Predix platform, Siemens' MindSphere platform, and Cisco Systems' Fog platform. To these we can probably add Bosch's Connected Industry platform in the automobile industry and Komatsu's KOMTRAX platform in the construction industry. In any case, the platform is supported by the CPS-5 design concept. Each company envisions its platform evolving into a node connecting a wide variety of things and services.

Personal computers and smartphones for which Windows, Android OS, and Apple's iOS have become connecting nodes are no more than ecosystems for specific types of products. On the other hand, the integrated service platform of BP-5 serves as a large-scale connecting node (an OS in an IoT environment) that interconnects all sorts of industries. It will create a huge business ecosystem in every corner of the global market.

4. Making Japan and Japanese companies excel in IoT era

In this section, I address the issues that Monozukuri in Japan is now facing and propose a direction that Japan should take to excel in the IoT era.

<How can Society 5.0 be transplanted to the forefront of the market?>

Japan's 5th Science and Technology Innovation Basic Plan, which went into effect in 2016, defines a "super smart society" (Society 5.0) as the direction that Japan should take. It also defines an IoT service platform for linking cyberspace and physical space as a common infrastructure technology. This looks to be a landmark event in terms of a policy promoting innovation in Japan.

However, this is still just an abstract concept talked about from an "altitude of 100,000 meters." For businesspersons and policy makers to connect this policy to added value, productivity, employment, and economic growth, it will have to be translated into viewpoints at lower altitudes of 100 meters, 10 meters, and even 1.5 meters (the viewpoint of a business person). The concepts shown in Figures 1 and 2 would certainly be effective in providing such a translation, but there are few architect-type software engineers who can bring Society 5.0 to the forefront of the global market.

<How can software architects be developed?>

In Japan, there are many excellent engineers of embedded software. This is because in the 1990s, when human resource development could not keep up with demand, help came in the form of highly professional engineers from the fields of mechanical engineering and electrical engineering. This is the background to the competitive edge that Japanese companies currently possess in CPS-1 (Figure 2). However, the personnel needed for CPS-2, CPS-3, CPS-4, and even CPS-5 and personnel who can make Society 5.0 a reality in the market are architect-type software engineers having advanced computer science skills. Unfortunately, Japan still suffers from a lack of such engineers.

First, while there may be no option at present but to go study in the United States computing education should be added to the curriculum from elementary and middle school on. A person with no computing skills will be hard-pressed to find employment in high-added-value work in the many industries. According to "The Future of Jobs"[4] report published by the World Economic Forum, 7.1 million jobs will be lost by 2020 in 15 major countries and regions as industry shifts to artificial intelligence (AI), robotics, Industrie 4.0, etc., while no more than 2.1 million jobs will be created in growing fields.

In Japan, as well, while computing education is scheduled to begin in elementary and middle schools in 2020, a failure to broaden personnel training and computing education for workers may lead to severe social polarization.

The countries that excelled during the second economic revolution were those that emphasized science and technology and focused on human resource development heavy in basic science and technology. Now, 100 years later in the third economic revolution, the countries that excel will be those that stress the development of a workforce with computer-science and computing skills. These countries will foresee changes in the social system brought on by IoT, identify directions toward addressing key issues, establish effective policies before other countries, and implement those policies efficiently in the form of real-world business.

In 2020, which is only a few years away, 63% of the occupations held by engineers in the United States are predicted to be in computing fields.[5] In the computer science departments at leading universities in the United States, more than 60% of the students in doctoral and post-doc programs are Chinese or Indian. We must take this reality in stride and proactively pursue the development of architect-type computing personnel.

<How can Japan deal with a fundamental change in enterprise system?>

The development of large-scale business enterprises began at the end of the 19th century with the rise of the second economic revolution, which brought economic rationality in the form of an enterprise system. In this period, the "visible hand of management," as described by Alfred D. Chandler, Jr., came to play a leading role.[6] This system, however, has been losing its economic rationality and the traditional concept of the visible hand has been becoming dysfunctional since 1990s with the rapid advance of the third economic revolution. What is needed from here on is the concept of the "extending hand of management" based on the open-close strategy for ecosystem-based vertical integration. Many European and American companies including Boeing, General Motors, Intel, and Bosch as well as Toyota and Komatsu have made the transition from a full-set type vertical integration to an ecosystem-based vertical integration in the pursuit of economic rationality.

However, an enterprise system is completely different from anything in the past because the software-based CPS concept captures added value in the IoT industry. It is still fresh in my mind how Siemens, which was once a pure manufacturing enterprise, declared in 2007 that it would become a software company. It has recently begun to free itself of business domains related to "things" one after another, such as factories, production lines, assembly/processing facilities, jigs and tools, and materials as well as supply chains and communication infrastructures.

Instead, Siemens is treating design tools such as computer-aided design/computer-aided manufacturing (CAD/CAM), manufacturing facilities, process control, production systems and their control functions, maintenance services, and even logistics operations not as things but as digital information, which is creating new business value in cyberspace. In short, it is letting go of "physical things" and attempting to transform itself into a service business. In this way, it is dynamically changing its management strategy to a new "extending hand" format that represents things in cyberspace from which it controls the market of physical things. This is a goal of their CPS business strategy.

Without the burden of having physical things, a company's operations are less affected by market fluctuations and are thus more stable. With digital information, as opposed to physical things, inventory control becomes much easier and gross profit (added value) increases. A company that is not investing in things has no need to include depreciation in costs. Return on equity (ROE) becomes very high, resulting in stable management. Stock market capitalization can also rise significantly if ROE can be made high and management stabilized. This explains why ROE is very high for European and American enterprises.

For example, in the 2010s, companies like General Electric, Siemens, and Bosch, in addition to developing high-productivity factory systems as physical things, simultaneously developed and represented the physical things themselves as digital information in cyberspace. The idea was to digitize know-how and protect it in a closed area while providing physical factory systems as full turnkey solutions to under-developed countries. At this time, European and American enterprises had the computing ability to constantly enhance know-how on the operation of production elements and to represent that know-how in cyberspace. They also had the organizational ability to enhance production solutions and represent them in cyberspace. In this way, it can be said that a company's closed area is not a thing as such but something concealed in cyberspace. Open-close strategic thinking has evolved to this point.

While it may sound easier to deny this trend and simply go back to basics by pursuing physical Monozukuri, Japanese enterprises would then have to compete on the basis of productivity with other Asian enterprises. This accelerating wave of drastic changes in industrial structures that hit the United States in the 1980s and Europe in the 1990s is fast approaching Japanese enterprises, and the changes go far beyond the changes in the IoT era.

There are many issues that need to be addressed to enable Japanese enterprises to excel in the IoT era, but they can be handled if policy makers, businesspersons, and academics participate in the discussion. In general, the Cabinet Office and the ministries and agencies in Japan formulate policies to solve specific issues, but it is the role of businesspersons to apply those policies to business issues in the IoT economic environment.

Needless to say, there is much expectation of Fujitsu as a representative of the Japanese information and communications technology (ICT) industry to spearhead this effort. At the same time, we members of academia must not limit ourselves to simply recording and interpreting the past. We must also examine directions to take for addressing issues from a historical and global perspective and continue to propose practical measures and policies.

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