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IoT Accelerates Shift to Manufacturing Services

— Corporate strategy in the era of data —

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〈Summary〉

◆ Although the importance of service-oriented manufacturing has long been pointed out, discussions so far have focused on the significance of service-oriented manufacturing and the introduction of examples of individual companies. This paper provides a quantitative understanding of the transition of Japan's manufacturing industry to a service industry, and views the future direction. The shift to services in the manufacturing industry is sometimes discussed in terms of inputs, such as an increase in the number of workers involved in the provision of services, but this paper focuses on the shift to services from the perspective of sales.

◆ According to the Census of Manufacture, conducted by the Ministry of Economy, Trade and Industry (METI), the growth of service income in Japan's manufacturing industry accelerated after the beginning of the 2010s. In 2017, the most recent year, service income reached 1.1 trillion yen, about 3 times that of 2010. Mainly in the machinery sector, services for equipment sold to customers, such as maintenance are leading this growth. It can be pointed out that these services are expanding because (1) there is a growing need on the user side to externalize maintenance due to the retirement of skilled engineers and a shortage of workers, and (2) the development of IoT technology has made services more efficient and sophisticated. In services using IoT data, in addition to maintenance, support for optimization of product operations, such as energy-saving operation, is now seen in many cases.

◆ In recent years, companies have been exploring new ways to turn IoT data into services. Leading companies such as Fanuc, Komatsu, and Daikin have embodied initiatives that aim

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to optimize the entire plant, construction site, or office space beyond the optimization of individual products. By collaborating with multiple companies to create a platform and making use of diverse data, they are trying to provide services that are more convenient for customers. In this way, the shift to services in the manufacturing industry, where data plays a central role, is expected to accelerate further as a result of (1) further development of IoT technology, (2) changes in society due to the novel coronavirus (COVID-19) pandemic, and (3) penetration of the circular economy.

◆ The service-oriented manufacturing industry using platform data is in its infancy globally, and there is a good opportunity for Japanese companies to gain an advantage. While only a handful of companies can be platform players, many other companies can compete in this new space by providing products that extract data smoothly, or are robust enough for long-term use, or by providing products and services that are optimized based on data from the platform.

● **This is a English version of "IoT で加速する製造業のサービス化 ― データ主役時代の企業戦略 ―" in JRI Research Focus (The original version is available at https://www.jri.co.jp/MediaLibrary/file/report/researchfocus/pdf/12011.pdf)**

1. Introduction

Against the backdrop of changes in the business environment, such as the emergence of companies from emerging countries in Asia and the commoditization of goods, it has been pointed out for many years that the shift to services in the manufacturing industry is important for Japan's manufacturing industry to maintain and improve its international competitiveness.

In past discussions, the significance of the shift to services and analysis of individual companies' cases have been the main focus. In this paper, we use macroeconomic data such as METI's Census of Manufacture to grasp the shift to services in Japan as quantitatively as possible, point out the current trends that are taking place in Japan, and review the future direction.

In this paper, we focus on the service-oriented approach from the perspective of sales, which is to increase service revenues in the manufacturing sector. Service-oriented approaches in the manufacturing sector are sometimes referred to as service-oriented approaches in terms of inputs, such as an increase in the number of employees involved in service provision (sales, planning and development) in the manufacturing sector and an increase in the ratio of tertiary industries in intermediate inputs.

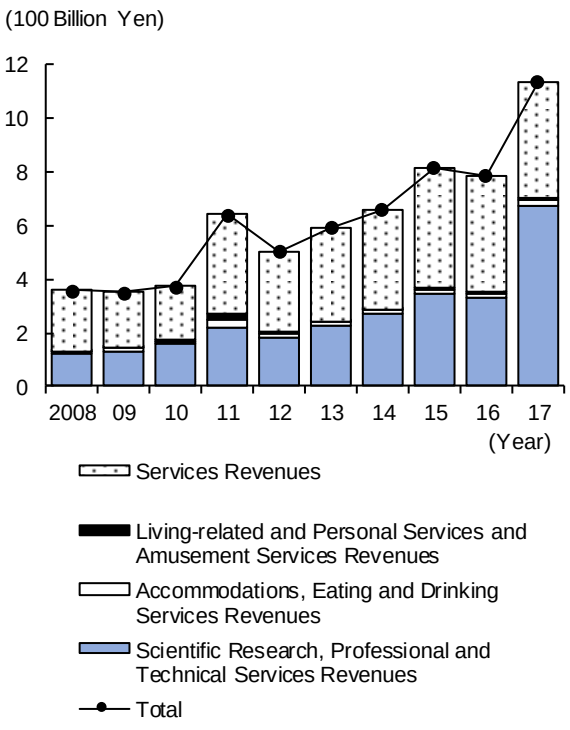
2. Increased services for own products by machinery manufacturers

The Census of Manufacture, one of the most comprehensive surveys of the Japanese manufacturing industry, provides detailed item-by-item statistics for manufacturing establishments (4 or more employees) in Japan. Most of these are shipments of products, but various service revenues are also included in the "Other income" category.

Since the Census of Manufacture is a survey of manufacturing industry at the business establishment level, income from service subsidiaries and sales companies belonging to the manufacturing industry's corporate group is not included in the survey. Although this point needs to be kept in mind, the actual situation of service revenues of the Japanese manufacturing industry as a whole can be outlined by accumulating various service revenues from the Census of Manufacture.

According to this, service revenues of Japan's manufacturing industry expanded significantly after the beginning of the 2010s, and in the most recent year of 2017, they reached 1.1 trillion yen, approximately 3 times that of 2010 (Figure 1, Chart 1). In 2017, it was up 44% year-over-year. This was a sharp increase from the previous (2010 – 2016) annual increase of 13% on average, and it is impossible to exclude the possibility that some special factors have affected this. Nevertheless, we can safely conclude that the trend of expansion continues.

Figure 1. Services Revenues from the Manufacturing Industry



Source: Ministry of Economy, Trade and Industry "Census of Manufacture"

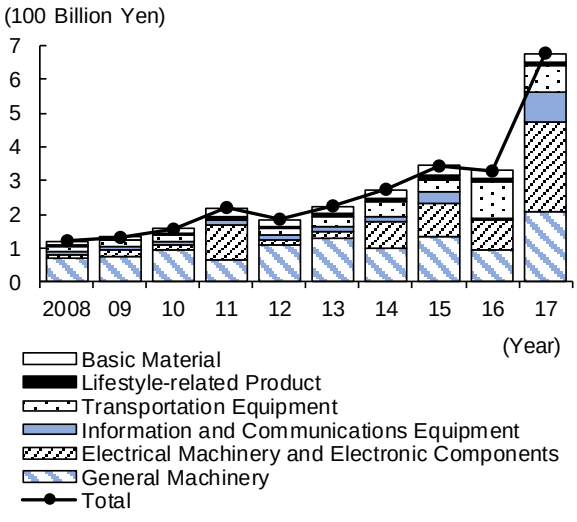
Table 1. Classification of Service Revenue

Scientific Research, Professional and Technical Services Revenues	Test and Research, Product Inspection, Measurement, Measurement Certification, Management Consulting, Advertising, Design, Mechanical Design, Building Design, Plant Engineering, Plant Maintenance, Maintenance, Inspection, Etc.
Accommodation, Eating and Drinking Services Revenues	Restaurants, Inns, Hotels, Boarding Houses, Takeout Food Services, Etc.
Living-related and Personal Services and Amusement Services Revenues	Laundry, Barber, Beauty, Washing And Dyeing, Garment Sew ing Repair, Food Processing, Travel Agency, Housew ork Service, Industry Association, Sports Facilities, Parks And Playhouses
Services Revenues (Other Exposures)	Cleaning, Waste Treatment, Iron Scrap Crushing, Ship Dismantling, Liquefied Gas Filling, LPG Filling, Postage Stamp Sales, Stamp Sales, Building Maintenance, Industrial Facility Cleaning, Etc. * Excluding Income From Intellectual Property

Source: Prepared by JRI from "Census of Manufacture" Ministry of Economy, Trade and Industry

The growth in manufacturing service revenues was driven by the "Income from Scientific Research, Professional and Technical Services" of professional services. Looking at the breakdown by industry, it is characteristic that most of them are in the mechanical sector (Figure 2). The machinery sector accounts for less than half of the total value of shipments (46%) of the manufacturing sector, but accounts for as much as 95% of scientific research, professional and technical services revenues. Income from scientific research, professional and technical services includes a wide range of services by definition. However, since most of the services are in the mechanical industry, it is believed that the services are mainly for equipment sold to customers, such as maintenance.

Figure 2. Industry Breakdown of Scientific Research, Professional and Technical Services Revenues earned by Manufacturers

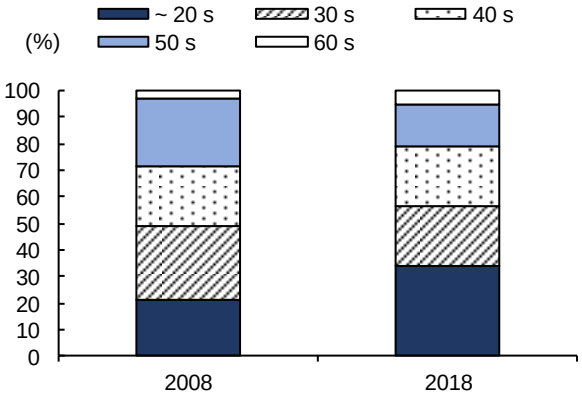


Source: Ministry of Economy, Trade and Industry "Census of Manufacture"

The first reason for the increase in services for the company's products, such as maintenance, is that there has been a growing need to outsource maintenance, etc. on the user side due to the retirement of skilled engineers and a shortage of workers. In the 10 years from 2008 to 2018, the proportion of workers in their 50s or older decreased while that of workers in their

20s increased (Figure 3). With the retirement of many experienced engineers who are knowledgeable about all aspects of plants and plant equipment and are able to respond flexibly, and the increasing number of young engineers with limited experience, there has been a growing trend to ask manufacturers and others to perform part of equipment maintenance work. In addition, the labor shortage caused by the declining working-age population accelerated the outsourcing of maintenance work. For example, in the transportation industry where labor shortages are particularly severe, it used to be common for drivers to perform maintenance of truck tires and the like, but in recent years, there have been an increasing number of cases in which maintenance is entrusted to tire manufacturers and drivers concentrate on driving.

Figure 3. Age Composition of Conservation Sectors



Source: Japan Institute of Plant maintenance

Second, the increased efficiency and sophistication of services through the spread of IoT also accelerated the expansion of services for their own products by the machinery industry. IoT has made it possible for machine manufacturers to collect data on machines operating at customers' locations without having to go there. By analyzing this data, it has become possible to efficiently detect signs of failure in advance (predictive maintenance), etc. When we checked the websites of all 917 manufacturing companies listed on the First Section of the Tokyo Stock Exchange (As of March 2020), we found that 39 companies provided services using IoT for their own products (Table 2). In recent years, as interest in IoT has increased, the number of such services has expanded, particularly among large enterprises.

IoT services cover a wide range of machines, including machine tools, semiconductor manufacturing equipment, industrial machinery, construction machinery, agricultural machinery, transportation machinery (trucks, ships, and tires), air conditioners, elevators, and office multifunction devices. In addition, the types of services are not limited to maintenance and remote monitoring, there are many services that support the optimum operation of machines sold by the company, such as energy-saving operation and minimizing material loss using data.

Table 2. Services for Own Products Utilizing IoT of Manufacturing Industry listed on the First Section of the Tokyo Stock Exchange

Company Name	Main Target Equipment	Service Name (Contents)
Asahi Kasei	Plant Machinery	e-LEONEX (Online Facility Diagnosis System)
Konica Minolta	Multifunction Machines For Offices	Managed Print Service
Idemitsu Kosan	Plant Machinery	Dr. PLANT (Predictive Facility Management)
Bridgestone Corporation	Tires	Transport Solution
Sumitomo Rubber Industries	Tires	Smart Tire Concept
MIURA	Boilers	ZMP (Maintenance)
AMADA HOLDINGS	Machine Tools	V-factory (Maintenance and Optimal Operation)
DMG MORI	Machine Tools	Digital Solutions (Maintenance And Optimal Operation)
Komatsu	Construction Machinery	KOMTRAX (Maintenance and Optimal Operation)
Hitachi Construction Machinery	Construction Machinery	Global e-service (Maintenance)
TOWA	Semiconductor Manufacturing Equipment	TEN-System (Maintenance)
Kubota	Agricultural Machinery	KSAS (Maintenance and Optimal Operation)
EBARA	Pumps	Remote Monitoring
Daikin Industries	Air Conditioning Equipment	Airnet Service System (Maintenance and Optimal Operation)
Kurita Water Industries	Water Treatment Equipment	Remote Monitoring Service
Tsubakimoto Chain	Conveyance Machines	TASCAL Maintenance Service
Fujitec	Elevators	New Gold Maintenance
Fukushima Galilei	Commercial Freezer Refrigerators	S-net 24 (Maintenance and Optimal Operation)
Amano	Parking Lot Equipment	Parking Web (Remote Control)
JTEKT	Machine Tools	IoE Solution (Maintenance and Optimal Operation)
Hitachi	Industrial Machinery	Lumada (Maintenance and optimal operation)
Mitsubishi Electric Corporation	Machine Tools	e-factory (Maintenance and Optimal Operation)
Fuji Electric	Industrial Machinery	Maintenance Station (Facility Maintenance Management System)
Yaskawa Electric Corp.	Industrial Robots	i^3 Mechatronics (Maintenance and Optimal Operation)
Omron Corporation	Control Equipment	i-Belt (Field Data Utilization Service)
YOKOGAWA ELECTRIC	Plant Machinery	Remote Maintenance Service
Azbil	Building Systems	Total System Maintenance Service
Sysmex	Inspection Equipment	Network Support Services
Fanuc	Machine Tools	FIELD system (Maintenance and Optimal Operation)
Kyocera Corporation	Multifunction Machines For Offices	Managed Document Service
Mitsui E & S Holdings	Ships	Maritime-SOL (Flight Support Services)
Hitachi Zosen	Ships	Remote Monitoring And Operation Support
Mitsubishi Heavy Industries	Industrial Machinery	Remote Monitoring Service
IHI	Industrial Machinery	Remote Maintenance
Isuzu Motors	Trucks	Preism (Maintenance and Optimal Operation)
Hino Motors	Trucks	HINO CONNECT
Canon	Multifunction Machines For Offices	Managed Print Service
Ricoh	Multifunction Machines For Offices	Managed Document Services
Tokyo Electron	Semiconductor Manufacturing Equipment	TELeMetrics (Maintenance and Optimal Operation)

Source: Prepared by JRI based on the websites of each company

3. Advent of the data-drive era

In recent years, companies have been further developing the use of IoT data and exploring new ways to develop services. While previous services have been designed to optimize the operation of their products, some leading companies are now embodying efforts to use data to achieve the broader optimization of factories, construction sites, and offices, beyond single products. In factories, etc., not only machines from a specific manufacturer are in operation, so in order to optimize the entire system, data cooperation among multiple companies is required. The following are the three examples of Fanuc, Komatsu, and Daikin Industries. All three companies have already achieved excellent results in IoT services for their own products, but with the aim

of further advancement of data utilization, they are each trying to establish a platform for linking data, etc. between companies and realize services of wider optimization.

Table 3. Examples of Platform Building Companies

Company Name	Flagship Product	Services for Own Products	Platform (Main Region)
Fanuc	Industrial Robots	ZDT	FIELD System (Factory)
Komatsu	Construction Machinery	KOMTRAX	Landlog (Construction site)
Daikin Industries	Air Conditioning Equipment	Airnet Service System	CRESNECT (Office)

Source: Prepared by JRI based on the websites of each company

(1)Fanuc: Factory case study

Fanuc Inc., a leading manufacturer of industrial robots and CNC (computer numerical controller) machines, announced in 2015 a new service called ZDT (zero downtime) that uses IoT to predict the failure of its industrial robots and other products in advance, so as to prevent any unexpected stoppage of production lines (downtime). ZDT has been widely accepted for its contribution to improving productivity by increasing the capacity utilization rate of customers' factories, and has been highly evaluated by receiving the Minister of Economy, Trade and Industry Award and the Minister of Internal Affairs and Communications Award at the Robot Awards 2018.

Fanuc, working with Cisco Systems, Rockwell Automation, Preferred Networks and the NTT Group to accelerate and expand the success of ZDT, launched its open platform "FIELD system" service in 2017. The FIELD system is characterized by (1) being able to connect not only Fanuc products but also other companies' products, and (2) recommending the provision of applications by third parties.

By making it possible to connect products other than Fanuc, customers can centrally manage the data obtained and managed separately for each machine or manufacturer using the FIELD system, making it easier to visualize the entire factory. In addition to ZDT, Fanuc has also been able to expand the range of services it can provide by releasing multiple applications on the FIELD system, such as PMA (Production Monitoring & Analysis), which analyzes the operation status of the entire factory and helps improve productivity.

In addition, Fanuc is opening up its FIELD system API to allow registered partners to offer applications. This creates an environment in which new applications are created one after another, leading to a virtuous circle that further enhances the value of the FIELD system. According to the company's homepage, the FIELD system already has more than 600 registered partners.

(2)Komatsu: Example of construction sites

Komatsu Ltd., a major construction equipment manufacturer in Japan, began testing the use of GPS in construction equipment in the late 1990s as a countermeasure against theft. The company then evolved the technology by adding sensors to the GPS as well. In 2001, the company adopted KOMTRAX as standard equipment for remotely confirming construction equipment. As a result, it became possible to grasp the wear

of parts and the remaining amount of fuel in real time, enabling efficient parts replacement and refueling, and it is considered to be a pioneering example of IoT services by a Japanese manufacturer.

In addition to improving the operational efficiency of its own construction equipment, in 2017 Komatsu established Landlog in a joint venture with NTT DOCOMO, SAP Japan and OPTiM in order to improve the productivity and safety of the entire construction production process. The joint venture company plans, develops and operates the platform "Landlog" and has established a system to manage the data of the construction production process in an integrated manner.

Landlog collects and accumulates not only construction equipment data but also various data on the environment, topography, materials, and staff. In the past, such data was managed by each operator at a construction site where multiple specialists were involved, and the data was in a fragmented state. Centralized management and sharing by Landlog is expected to facilitate cooperation among operators and contribute to overall productivity improvement. By utilizing the Landlog system, Komatsu itself has been able to obtain a wide range of data, including data on equipment other than construction machinery, thereby expanding the range of services it can provide. In addition, the openness of the Landlog API creates an ecosystem in which external application developers with a variety of ideas and strengths can provide applications on Landlog. In addition, a wide range of stakeholders, including finance, insurance, and trading companies, are involved in Landlog initiatives, and it is expected to contribute not only to the improvement of construction sites, but also to the improvement of a wide range of businesses surrounding construction, including procurement of materials, accounting, and finance.

(3)Daikin Industries: New era of office

In 1993, Daikin Industries, a major Japanese air conditioner manufacturer, released its "Airnet service system" a 24 hour monitoring system that uses an online diagnosis system to monitor the operating status of commercial air conditioners. Along with KOMTRAX of Komatsu, it is known as a pioneering example of IoT utilization in manufacturing industry in Japan. The Airnet Service System has enhanced its services by, for example, providing optimum automatic energy-saving control based on local weather data.

In February 2018, Daikin Industries announced the concept of a collaborative platform called "CRESNECT" with the aim of developing new value and services relating to air and space beyond its traditional role as an air conditioner manufacturer in controlling temperature and humidity by further developing its long history of data utilization and collaborating with other partners. In the future, they plan to offer services to a wide range of spaces, including stores, hospitals, and educational facilities, but for the time being, they will focus on developing services to improve productivity in office spaces and to support health. In order to realize a comfortable space, the temperature and humidity directly related to air conditioners are only a part of the necessary factors, and it is necessary to adjust various factors such as lighting, sound, smell, office furniture, and security in an integrated manner according to the movement and preferences of users. To achieve this, it is necessary to collaborate with partner companies that have strengths in their respective fields. Moreover, in order to collect various data on the space required for the provision of services (brightness, sound, number of people, position, movement, etc.), it would be costly to install sensors and communication devices separately

by each company, but by acquiring and managing data jointly using CRESNECT, the cost per company can be greatly reduced. In CRESNECT, air conditioners act as hubs for collecting spatial data. This is because IoT devices must be installed on ceilings with a view of the entire room, and air conditioning equipment with a power supply meets these requirements.

In July 2019, along with Okamura, Tokio Marine & Nichido Fire Insurance, Lion, MY CITY, Asahi Breweries, TOA, TOTO and Panasonic, Daikin Industries opened a members-type co-working space "point 0 marunouchi" in Marunouchi as a place to demonstrate various services. In addition to serving as a venue for service demonstrations, the space also functions as a venue for co-creation, a venue for marketing research, and a showroom where employees from multiple companies gather in the same space to introduce new services.

Coincidentally, with the spread of COVID-19 infection, telework has spread rapidly, and the office has entered an era in which its value is being questioned again. In other words, it has become clear that much of the work that was done in the office can be done at home, and in the office, there is a direction in which added value unique to the office is required, such as increasing productivity more intensively and demonstrating creativity through direct communication between people. In the CRESNECT initiative, partner companies with strengths in various fields are expected to jointly use spatial data and cooperate with each other to provide services that have not been available before, such as providing personalized spaces and supporting the activation of communication through spatial staging in accordance with TPO, thereby opening the way for a new era of office.

What is common among these three cases is that while the scope of data utilization and service provision is expanded from conventional own products to factories, construction sites, and offices as a whole, the required data and management resources for providing services are insufficient on their own, and they are forming platforms and collaborating with other companies. In this way, total optimization is achieved instead of individual optimization for each product, and the added value obtained by the customer is increased. For platform leaders, this could be a lucrative business model that gives them more data than they could ever get on their own, enabling them to offer new services, and charging a fee to partners who use the platform to deliver applications and services. Up until now, Japanese companies had tended to adopt a self-sufficiency policy, but advanced companies realized that this would not be the case in the future, and they began to aim for open innovation with other companies.

Looking to the future, it is expected that the shift to services in the manufacturing industry using such data will be further promoted by the following three factors.

The first is the further development of IoT technology. Smaller, cheaper, and more sophisticated sensors will continue to be used, and the practical use of 5G will greatly increase communication speed and capacity, making it easier to collect large amounts of data on objects in real time. In addition, the ongoing OPC[1], the development of standards for data exchange between devices is also expected to support various forms of data coordination between companies.

Second, changes in the business environment due to the COVID-19 pandemic. The spread of COVID-19 has made office workers and other workers move to telework, but many jobs, including at manufacturing sites, are

[1] An interoperable standard for secure and reliable data exchange in the industrial automation and other industries.

difficult to do remotely. From the perspective of BCP (business continuity plan), companies are becoming increasingly aware of the need for production activities that rely on "humans" and demand for services such as remote monitoring and control is expected to increase over the medium to long term. In the wake of the COVID-19 pandemic, the fragility of the supply chain, which has been excessively dependent on specific regions such as China, has again attracted attention. In order to be able to respond flexibly in times of crisis, it is expected to promote decentralization and diversification of supply chains, as well as to strengthen efforts to link data among enterprises and optimize operations.

The third is the shift to a circular economy (cyclical economy). With the increase in resource consumption due to the increase in world population and the improvement in living standards, it has become clear that the conventional linear economy based on mass production, mass consumption and mass disposal is not sustainable, and the formation of an international framework for the transition to a circular economy is being promoted mainly in Europe[2]. The demand for services such as maintenance is expected to increase in the circular economy because products are required to be used for a longer period of time without being discarded. On the other hand, manufacturers are required to shift their focus from product sales to the pursuit of profit opportunities through the provision of services, because a longer period of use means that sales of products will decrease. Subscription, which combines products and services, will also be an important option. It is also expected that efforts will be made to reduce waste losses by building production systems that respond quickly to fluctuations in demand using data.

4. Conclusion

As we have seen, Japan's manufacturing industry has made steady progress toward the introduction of services and will continue to advance with further sophistication. In particular, services that utilize data and aim to optimize not only individual products but also a wider range of products are in their infancy worldwide, including at overseas companies, and there are ample opportunities for Japanese companies to gain an advantage. I strongly hope that Japanese companies, such as Fanuc, Komatsu, and Daikin Industries, which are well versed in the use of data from products introduced in this paper, will play a leading role in the development of platforms and enhance their competitiveness.

On the other hand, only a handful of companies can become platform players in services where such data plays a central role, and many others need to work with platform players in a new environment to develop survival strategies. Specifically, it is possible to provide products that are easy to extract and utilize data from in a form that is compatible on the platform, and to provide products and services at an optimal timing by utilizing data obtained from the platform. In addition, as we shift to a circular economy, there is a possibility that the hardware strengths of the Japanese manufacturing industry, due to increased demand for robust products for long-term use, will be highlighted again.

[2] For details, refer to "Circular Economy Vision 2020" by the Ministry of Economy, Trade and Industry.