Special Contribution
Leading the Way: IoT Innovation in Japan and the World

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1. Introduction

Today, the Internet of Things (IoT) fascinates high-tech industries. Embedding small sensors in devices opens a new digital world. Visualization of the states and changes in things on a moment-by-moment basis that have heretofore been out of view should be of great benefit. One example is IoT technology adoption in manufacturing processes. Visualization of all the material flows in an assembly line delivers more efficiency than ever. Another example is the emergence of new IoT-related products and services in consumer markets that hold much promise for the future. Hence, many high-tech firms are keen to develop cutting-edge technologies and provide new products or services related to IoT.

One research question arises here: "In what IoT-related fields could Japan best apply its strong points and lead the way in global markets?" This paper answers this question. First, it surveys the present state of IoT innovation. Second, it focuses on mega-competition on a country basis. Finally, it discusses how IoT-related Japanese enterprises can raise their presence and contribute to Japan and the world.

2. IoT and innovation

Assuming that innovation can be described as "new combinations" as set forth by Joseph Schumpeter,[1] we can say that IoT innovation reflects new combinations of digital data. The combinations include all the linkages between things, between people, and between people and things.

One striking feature of IoT innovation is exponential growth of digital data brought about by new combinations and self-organization. It differs greatly from natural resources in that its carrying capacity is not limited. Big data technology enables massive amounts of data to be handled in the infinite world of cyber space. Another feature is that interfaces hold the key to creating new combinations. This is evidenced by the fact that firms often compete to establish their own interface technology as the de facto standard.

IoT innovation can be classified into three major types in terms of contributions to businesses and organizations. The first is the "in-house-usage" type in which a company uses data to support its core business such as manufacturing or marketing. The second is the "data/information-provision" type in which data is shared externally to provide broad benefits to society, and the last is the "revenue-generation" type in which digital products and services are created to generate revenue.

To determine the prevalence of these three types, we analyzed the 144 cases (excluding ones from overseas) covering not only IoT-related data but big data on the whole in the "Comprehensive List of Big Data and IoT 2015–2016"[2] and found that most were of the in-house-usage type with the remainder roughly evenly divided between the other two types. Next, we identified the keywords that expressed the distinctiveness of the three types. They were "analysis," "customer," and "prediction" for the in-house-usage type, "local government," "sensor," and "healthcare facility" for the data/information-provision type, and "development," "service," and "sales" for the revenue-generation type. These keywords revealed typical examples in big data usage: a) analyzing and predicting customer behaviors, b) providing useful data obtained from sensors to local governments and healthcare facilities, and c) developing products or services.

Figure 1 illustrates the results of correspondence

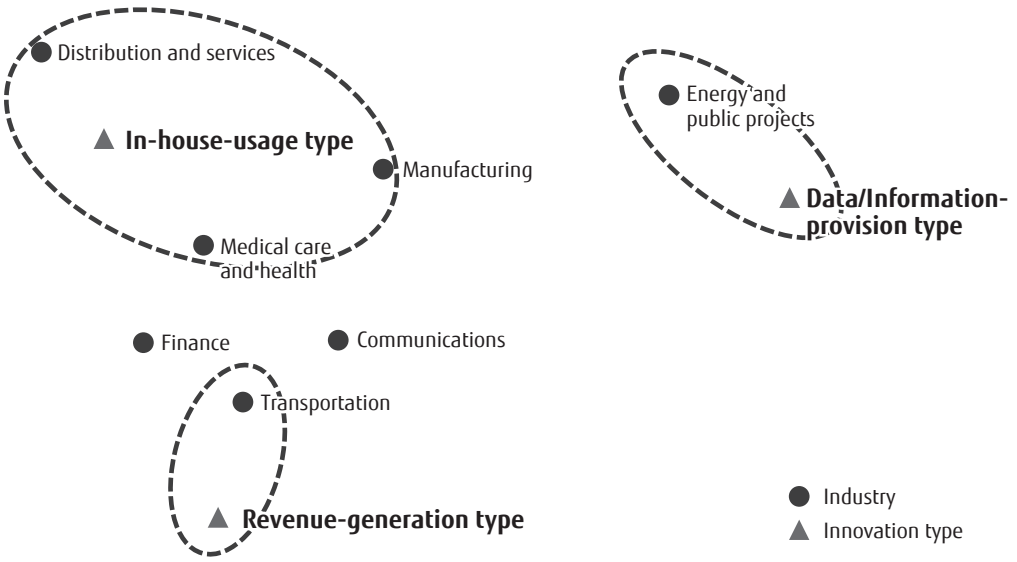

Figure 1
Directions of IoT innovation considering use of big data.

analysis among these three types and seven industries. Medical care and health, manufacturing, and distribution and services are plotted close to the in-house-usage type, energy and public projects are plotted close to the data/information-provision type, and transportation is plotted close to the revenue-generation type. We expect that a wide variety of relationships among these three types of IoT innovation will emerge in the near future in a way that will enable digital devices such as smart appliances and wearable terminals to be combined with consumer-oriented services.

3. IoT and mega-competition

The United States is leading IoT Innovation while Germany is taking the initiative for the Industrie 4.0 concept.[3] Turning our eyes to Asia, we see that China is trying to catch up with them. China's "Made in China 2025" strategic plan[4)–6)] (announced in May 2015) focuses on upgrading its manufacturing industry. Recognizing that Chinese industry is "大而不强" (large but not strong), this plan aims at transforming China into a manufacturing power by 2025 and into a world leading manufacturing power by 2049, the 100th anniversary of the founding of the People's Republic of China. The plan uses the expression "物聯網" (roughly translated as IoT), and its usage clearly reflects moving toward the fusion of manufacturing and ICT. Despite the fact that China's economy has been slowing down its market potential remains huge. China is poised to become a driving force in Asia in the long run and to become a leader in IoT innovation, along with the United States and Europe.

To capture the IoT trends in Japan, the United States, Germany, and China, we extracted IoT-related articles that appeared in those countries from the FACTIVA[7] news database (that is, articles that included "IoT" written in the language of each of those countries). For the period from 2011 to July 2015, we extracted 12,754 articles for the United States, 5,165 for Germany, 3,933 for Japan, and 802 for China. Next, to gauge the degree of mutual impact among these four countries, we analyzed the number of references to articles from each of the other three countries. In all cases, the number of references to articles from the United States was overwhelmingly large, with the percentage of references to the United States by China being particularly large (**Table 1**). In contrast, Japan had a low profile: the percentage of references to Japan by China, the U.S., and Germany was 1.4%, 1.0%, and 0.3%, respectively. These percentages were all lower than those to China.

Figure 2 shows co-occurrence networks spanning more than one country of company names appearing in the extracted articles. The major IoT players consist

of sensor-related equipment vendors (■), ICT vendors providing hardware, Web, and software products and consulting services (●), mobile communications carriers and vendors (▲), and other telecom carriers and vendors (◆). While the U.S. companies have a particularly high profile, there are some Japanese companies including ICT vendors such as Fujitsu, mobile communications carriers, and semiconductor solutions vendors.

Table 1
Mutual reference percentages among four countries.

A	B	A references B
China	US	23.5%
Japan	US	14.6%
Germany	US	10.6%
Japan	China	5.9%
US	China	3.7%
Japan	Germany	2.6%
China	Japan	1.4%
Germany	China	1.3%
US	Japan	1.0%
US	Germany	0.7%
Germany	Japan	0.3%
China	Germany	0.1%

4. IoT as a new driving force to enrich industries

Given that the essence of IoT is connections among things and people, we see the network effect (in which benefits to network participants increase as the scale of the network grows) everywhere. The network effect transcends geographical boundaries. If a company does not expand its share on a global level, it will inevitably fall victim to natural selection—smartphones and social media are clear examples of this phenomenon. Accordingly, Japanese IoT-related companies should target global markets.

Looking overseas, China embraces a huge domestic market that is the hub of people, things, and money in Asia. The growth rate and market scale of e-commerce (EC) in China, typified by the Taobao and Tmall websites, are far greater than those of Japan due to

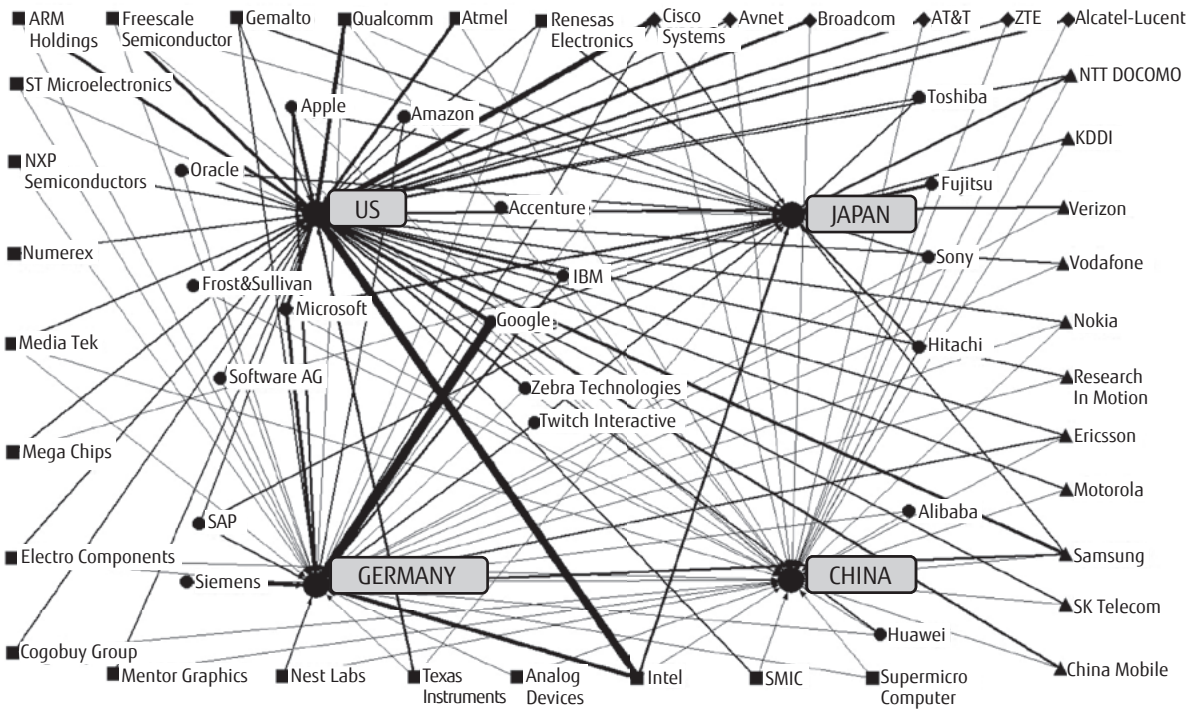

Figure 2
Major IoT players and state of mega-competition.

full-scale cross-border operations. In contrast, among countries with a mature economy, Japan is becoming a "grocline" (growth and decline) country where the combination of individual growth and social decline occur together.[8)]

In the 1970s, we Japanese called semiconductors the "rice of industry" (which means that semiconductors worked as a new driving force, first enriching all industries and then individuals and society). The IoT era will likewise foster product innovation and process innovation, making the sensors embedded in things and the data obtained from those sensors a new "rice of industry." To be more specific, we envision two directions for diffusion of IoT innovation: 1) the embedding of sensors in existing products and processes and 2) the creation of new markets through new IoT-related products or services. In both cases, the greater the degree of data integration and coupling, the greater the network effect, which will strengthen existing businesses and accelerate new business opportunities.

1) Embedding sensors in existing products and processes

Japan seeks to fortify its traditional strengths by embedding sensors in products having the brand power of "Made in Japan" to augment added value and by incorporating the results of analyzing the data obtained from those sensors into existing procurement, manufacturing, distribution, and marketing processes. Substantial efforts can be seen in some products such as automobiles, electrical products, and precision equipment and associated manufacturing sites. Moreover, if we take a look at export goods, tourism-related commerce, and cross-border EC, IoT has the potential of being put to good use in services targeting global customers and in the maintenance of purchased products.

2) Creation of new markets through new products and services

Japan also seeks to develop novel IoT-related products, services, and solutions and to expand globally. For example, responding to the grocline situation involves various latent needs: a) business needs including dramatic improvement in productivity commensurate with a smaller work force and support for labor-intensive industries such as agriculture and fishing, and b) individual needs including creature comforts related to food, clothing, and shelter, health and welfare services, and the creation of smart cities. In addition, Japan has already accumulated more knowledge and know-how on post-disaster restoration than any other country, which can be used to drive innovative services in this area.

Furthermore, IoT technology will surely open new possibilities when dealing with legal, political, economic, and socio-cultural changes, or when supporting major events like the Olympics. IoT technology can also be effective when coping with global issues common to the world. To give one example, the historical consensus reached at the 21st Conference of the Parties (COP21) held in December 2015 (also known as the "2015 United Nations Climate Change Conference") should add momentum to each participating country's response to the problem of global warming. This means that data collection and monitoring for all activities related to sustainability will become crucial. Since many Japanese enterprises have already been achieving remarkable results in terms of sustainability, we can expect further development of advanced solutions by combining IoT technology with practical wisdom acquired to date.

Japan can make a global contribution in many fields. Nonetheless, Japanese firms have often been left out of international trends due to Japan's failure to spread their innovative ideas globally. Japan must overcome its Galapagos syndrome and improve its ability to disseminate information abroad and market its capabilities. Also, Japanese firms need to adopt a "born global" strategy that targets the entire world from the very start in order to reach global markets without delay.

5. Conclusion

A particular strength of Japanese firms is the ability of their highly motivated employees to maintain a firm's international competitiveness in terms of manufacturing and service quality in the face of many challenges including strong-yen situations that have caused the hollowing out of manufacturing functions several times and natural disasters like the 2011 Great East Japan Earthquake. Superb quality starts at *gemba* (a place where human activities are conducted in a factory or an office) and is supported by a loyal and professional workforce. The time has come for Japan to take a leadership role in IoT innovation, despite

the mega-competition taking place, by leveraging its strong organization capabilities and to contribute to the world by quickly adapting to technology and market changes.

Fujitsu's strength lies in its products, solutions, and services, which combine hardware, software, and network technologies. As shown in Figure 2, Fujitsu is well positioned to collaborate on equal terms with major players worldwide and to serve as a pioneer, opening up a new era of IoT innovation.

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