Chapter 3

Changes Brought About by the 4th Industrial Revolution

In this chapter we will provide an overview of the potential, etc., of the changes brought about by the 4th Industrial Revolution. Furthermore, based on the results of surveys and research carried out on domestic and international companies focusing on industry and human resources in relation to changes that are expected to result in the area of industrial structure and the roadmap required for Japan to realize its "4th Industrial Revolution," we suggest directions that should be taken and issues that need to be worked upon, while anticipating the arrival of the age of the 4th Industrial Revolution. Furthermore, in order to be able to accept the results of the reforms realized as a result of the 4th Industrial Revolution, we believe it will be advantageous to not only learn from previous industrial revolutions, but also for those involved to share their ideas and directions based on quantitative indices. From this perspective, and based on analysis of Input-Output Tables, etc., we consider issues such as the digitization of industry, as well as the economic impact of the reforms resulting from the 4th Industrial Revolution.

Section 1 Global Trends Brought About by the 4th Industrial Revolution

This section looks at an understanding and definition of the 4th Industrial Revolution based on global discussions and trends, and provides an overview of activities taking place both in Japan and overseas.

1. Global Activities Based on the 4th Industrial Revolution

In January 2016, the annual general meeting of the 46th World Economic Forum (hereinafter WEF) was held in Davos, Spain. This meeting, generally known as the "Davos Conference," took its main theme as "Mastering the Fourth Industrial Revolution," and there were discussions for establishing a definition.

At the Davos Conference in January 2017, too, debate focused on the 4th Industrial Revolution, and how this Revolution, which hinges on artificial intelligence (AI) and robotics, should progress. The 4th Industrial Revolution is expected to bring about historical reforms in many areas, not only industry, but also labor and lifestyles, and various countries, including those in Europe and the US, are already pressing ahead with strategies to respond.

In Japan, too, plans including the Cabinet-decided "Japan Revitalization Strategy 2016," the "Basic Policy on Economic and Fiscal Management and Reform 2016" and "Japan's Plan for Dynamic Engagement of All Citizens", all focused on the 4th Industrial Revolution as policies for growth. The "Growth Strategy 2017," adopted by the Cabinet in 2017, which provides a new strategy for growth, also includes the realization of Society5.0 as a key to Japan moving out of long-term stagnancy and into mid- to long-term growth, for which the innovations of the 4th Industrial Revolution (IoT, big data, AI, robotics, the sharing economy etc.) need to be incorporated into various industries and activities within society.

The government understands the need to proactively press ahead with the realization of Society5.0 through partnerships between the public and private sectors.

Figure 3-1-1-1 Characteristics of Industrial Revolutions

1st Industrial Revolution	2nd Industrial Revolution	3rd Industrial Revolution	4th Industrial Revolution
18th century to early 19th century Mechanization in light industry, such as steam engines and spinning machinery	Late 19th century Oil, electric power, and heavy chemical industries	Late 20th century Emergence of the Internet, rapid dissemination of ICT	21st century Industrial revolution through extreme automatization and connectivity

* Davos Conference UBS White Paper (January 2016)
"Extreme automation and connectivity: The global, regional, and investment implications of the Fourth Industrial Revolution"

(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

2. Trends brought about by the 4th Industrial Revolution

In previous sections overview, the arrival of the 4th Industrial Revolution is focused on in various countries around the world. In this section, we look at the characteristics of trends brought about by the Revolution, and consider why the 4th Industrial Revolution is happening "now."

(1) The Development of a "Connected Economy"

The rapid growth of the internet has created a society in which many things are connected. This used to be referred to as "ubiquitous," but has now evolved even further. At the same time, as can be seen from concepts such as IoT, digitization and networking within manufacturing infrastructure, logistics and a wide range of industries supply chains has connected manufacturing facilities and logistics (the "supply" side) and consumers (the "demand" side) using ICT, allowing the efficient creation of manufacturing structures. In this way, the "connected economy" is beginning to demonstrate more specific trends.

(2) Developments in Open Innovation

In order to manifest the 4th Industrial Revolution within the social economy, the importance of promoting innovation that leads to increased and new demand, and the continued creation of new goods and services has been pointed out. In Japan, which faces structural issues caused by, for example, a declining population, it is vital to actively nurture innovation that will bring about changes within the social economy, and realize an innovation-driven economy, in order to stimulate future growth. In particular, business matching of consumers and suppliers across industries and sectors through networks and technology will require the development of new businesses that straddle conventional corporate boundaries, the utilization of external human resources with specialist, advanced skills, or the promotion of "open innovation."

(3) Progress in Alliances and Corporate Takeovers

The German Industry4.0 strategy focuses strongly on both "vertical partnerships" and "horizontal partnerships" within manufacturing industries. "Vertical partnerships" involve the philosophies conventionally adopted within the Japanese manufacturing industry, of supply chains etc. "Horizontal partnerships" on the other hand, involve a situation that works beyond the bounds of individual corporations, in which the necessary amount of the necessary resources at the right time can be acquired from all companies. These "vertical" and "horizontal" partnerships are not limited to manufacturing, but can be developed through a variety of industries. The creation of "colleagues" within the same technical sector or group of technologies, and the formation of de facto groups, through the standardization and opening of technologies, allows the formation of ecosystems and is expected to accelerate markets.

(4) The Impact on Various Sectors

The 4th Industrial Revolution is expected to impact various industries. In this section, we consider the types of business sectors and industry expected to be on the receiving end of this impact, and define a specific image of their future.

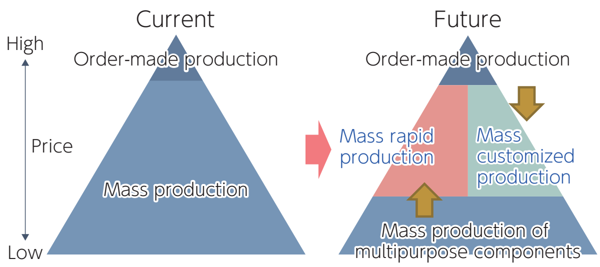
A. The Manufacturing/Logistics Sector

The manufacturing and logistics industries, and in particular the B to C aspects of these industries share data regarding consumer tastes, allowing the optimization of supply chains, which is expected to lead to reforms in industry structure. From this, it is anticipated that from conventional mass production systems, "mass rapid production" will develop, with a focus on the speed of manufacture, and development allowing to differentiate itself from manufacturing industries in emerging economies, and "mass customized production," in which products can be made to order for individual customers, at the same cost as standardized products. At the same time, it is anticipated that the supply chain will be optimized and production value will increase (see Fig. 3-1-2-1). It could be said that not only increased efficiency in development and production processes, but also evolutions in connection to and processes relating to the "demand side" are what comprise the new face of the 4th Industrial Revolution.

B The Financial Sector

Financial services are currently subject to trends in the area of "FinTech" (a combination of finance and technology), which affects not only corporate finance,

Figure 3-1-2-1 Changes within the Manufacturing and Logistics Sectors



(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

but also individual investment, small and medium enterprises (EC stores etc.) and venture corporations, which start up of new businesses, by enabling progress towards the provision of optimized services. In Japan and other developed countries the financial sector is pressing ahead with the publication of bank APIs (Application Programming Interfaces), known as "open API." Open API facilitates the safe and secure utilization of information owned by banks by FinTech corporations, and it is anticipated that it will lead to expansion within new accounting services such as account management and electronic money transfers, etc. In Japan, proposals revising the Banking Act were passed in May 2017. These promote open innovation within financial agencies and FinTech corporations, while protecting users, and it is anticipated that these activities will continue to accelerate in the future.

Section 2 Initiatives and Challenges for the 4th Industrial Revolution

In this section, we introduce some of the wider issues and measures being taken in regard to the 4th Industrial Revolution. For example, we perform an international comparison, such as issues considered to present restrictions by corporations introducing IoT looking at in-house internal factors, and external factors, such as systems and infrastructure, etc. In addition to this, a survey of domestic companies was collated, with general companies and ITAC companies, implementing innovative measures, considered separately, and analyzed.

1. Corporate Awareness of the 4th Industrial Revolution, and Measures Being Taken

In this section, we provide a comparative overview of opinions and awareness of the 4th Industrial Revolution among domestic and international companies, and consider the current status quo and future directions.

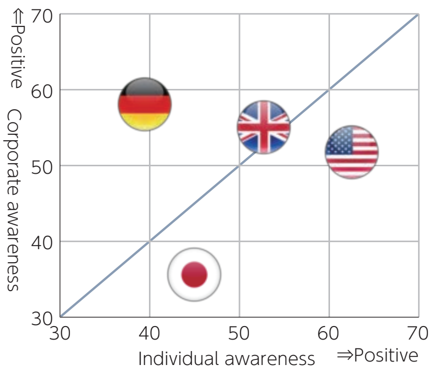
(1) Expectations Regarding the 4th Industrial Revolution

Many have commented that the 4th Industrial Revolution, will bring about both reforms in society and changes to industrial structure, but there appears to be a gap between the awareness of individuals and that of corporations in different countries in regard to the level of expectation relating to the shape of society and industry.

In Japan, positive awareness in both individuals and corporations is lower than that overseas, and in particular, that of corporations is lower than that of individuals. In Europe and the US (particularly in the UK and Germany), corporate awareness is high, and it is clear that corporations are playing a leading role (Fig. 3-2-1-1).

Domestic and international companies were asked in what countries, other than their own, they believed the 4th Industrial Revolution would bring about reform. The US was most frequently cited by companies of the UK, Germany and Japan, leaving other countries far behind, which suggests the fact that the US is broadly recog-

Figure 3-2-1-1 Individual and Corporate Expectations of the 4th Industrial Revolution[19]



	Individuals	Corporations
Japan	25.3	30.8
US	33.5	63.5
UK	28.9	70.1
Germany	22.6	76.3
South Korea	38.9	
China	42.6	

Japan: Individuals (N=770), Corporations (N=616)
US: Individuals (N=680), Corporations (N=107)
UK: Individuals (N=708), Corporations (N=107)
Germany: Individuals (N=709), Corporations (N=110)

*Deviation calculated from the results of responses from individuals and corporations in each country.
*"Don't know" responses excluded.

(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

[19] Deviation calculated from responses by individuals and corporations in different countries, based on proportion of responses selected from among "Extremely positive," "Fairly positive," "Neither positive nor negative," "Fairly negative," "Extremely negative" and "Don't know." "Don't know" responses were excluded from the data.

nized as the country that would lead and most benefit from the 4th Industrial Revolution.

It is noticeable that Japan comes second to the US in this evaluation. The response rate from corporations in three countries other than Japan was roughly the same. China, which was in third position, had the same average as Japan, but the response rate varied depending on the country, indicating a disparity in the evaluation. In this way, it is believed that Japan is expected, objectively by other countries, more than by its own corporations and citizens, to be one of the countries benefiting most from the 4th industrial Revolution, and that this should be strongly borne in mind. (Fig. 3-2-1-2)

(2) The State of the Response to the 4th Industrial Revolution

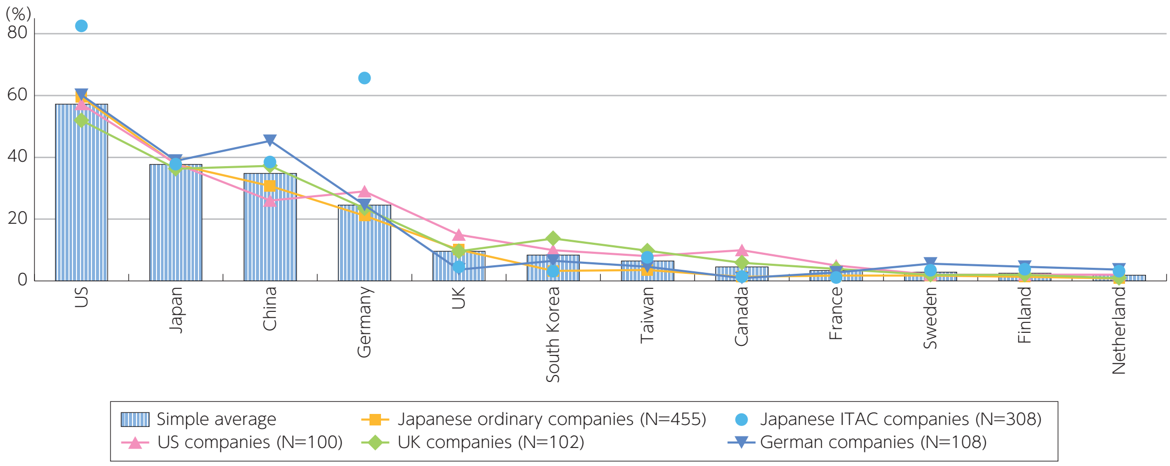
When corporations were asked to self-assess their own positions in terms of stages of working towards the 4th Industrial Revolution, both ordinary companies and ITAC companies in Japan responded the most that they were of the deliberation stage. Other countries are already at the introduction to base foundation stages. (Fig. 3-2-1-3)

(3) Future Directions in Response to the 4th Industrial Revolution

If we look at specific activities related to the realization of the 4th Industrial Revolution, a relatively high proportion of Japanese companies responded that they are now and will continue in the future to be engaged in reviews of their business, operation and organizations, as well as human resources strategies. Among non-Japanese companies, a large proportion responded that they intend to strengthen partnerships with external corporations.

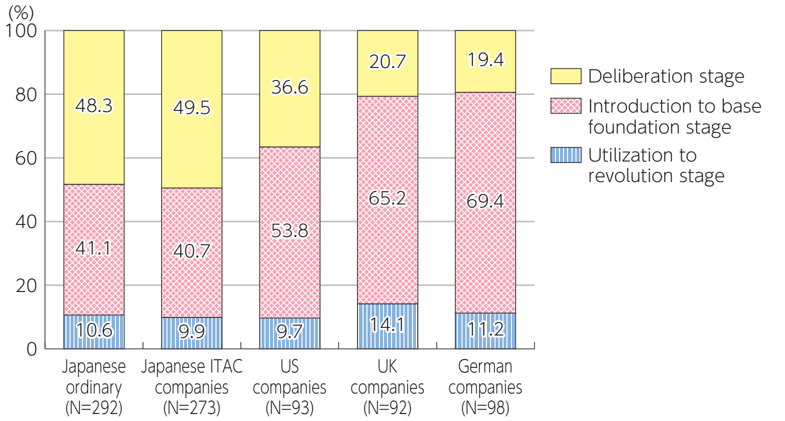
Increased investment by companies themselves is synchronized with the expansion in scale of markets in various countries as a result of measures relating to the 4th Industrial Revolution. In Japan, estimates of increased sales among ordinary companies are low, and at the same time there is limited level of self-investment anticipated when compared with other countries. If the focus is changed to ITAC companies, however, we see that they are at roughly the same level as companies in Europe and the US (Fig. 3-2-1-4).

Fig. 3-2-1-2 Countries expected to undergo reform as a result of the 4th Industrial Revolution



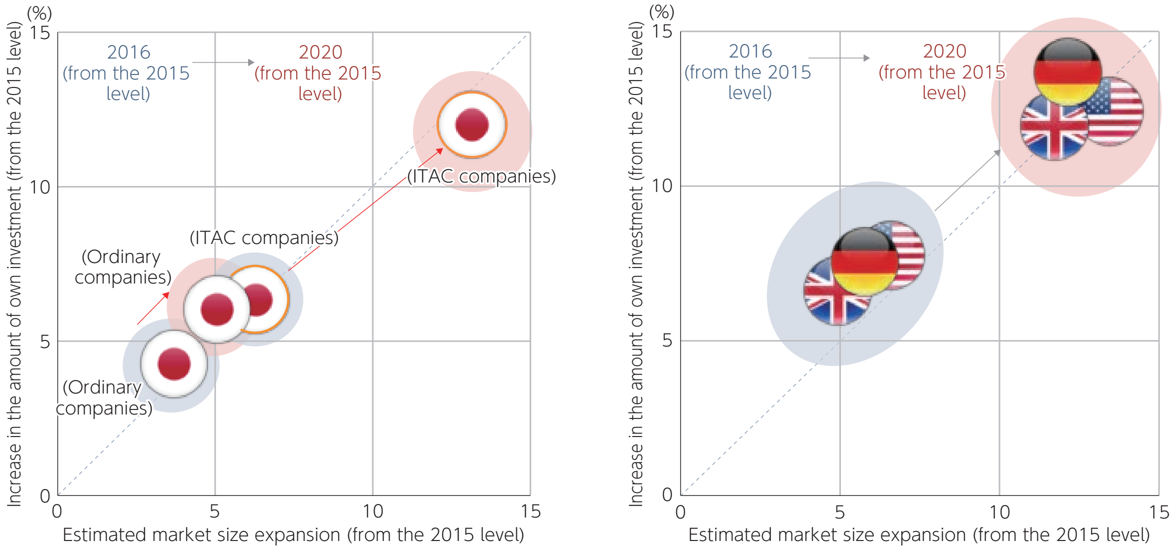
(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

Figure 3-2-1-3 Companies' stages toward the 4th Industrial Revolution



(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

Figure 3-2-1-4 Increase in Market Scale and Increased Investment in Response to the 4th Industrial Revolution



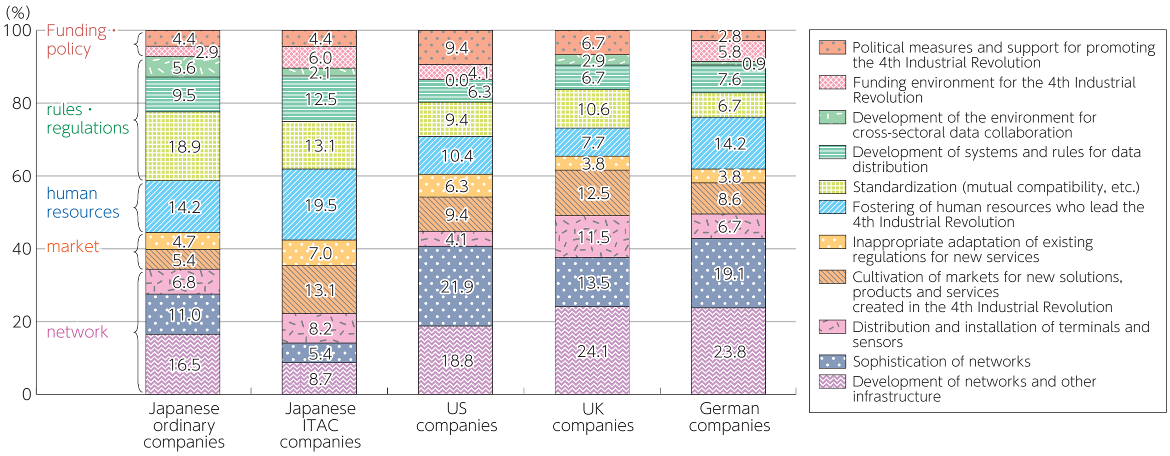
(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

2. Challenges to Realizing the 4th Industrial Revolution

The 4th Industrial Revolution will bring a huge trend to change to both society and the economy, through the processing and utilization of massive quantities of data, and there is a limit to what can be achieved independently by one or even multiple companies. As such, the challenges toward realizing the 4th Industrial Revolution are analyzed here, categorized into "external factors," which are dependent on conditions outside companies, such as rules, regulations, human resources and networks, and "internal factors," which include confidence, awareness, leadership and objectives, among other things.

Awareness of the issues relating to external factors was high among international companies in regard to networks, and infrastructure-related issues such as standardization and terminals At the same time, among Japanese companies, there was a high level of awareness of standardization, human resources development, and the rules and systems for data logistics and partnerships (see Fig. 3-2-2-1). In terms of internal factors, there was a significant difference in the level of awareness between international companies and Japanese companies regarding human resources and external resources.

Figure 3-2-2-1 Challenges in achieving the 4th Industrial Revolution (external factors)

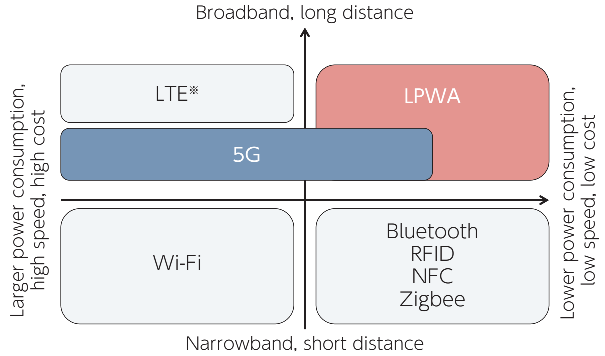


(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

Section 3 Development of IoT in the Information and Communications Industry

In this section, we provide an overview of the trends of new communications technology that supports the IoT, and provide trend analysis based on quantitative data of market trends at each layer of the information communications industry. Structure change is analyzed further.

Figure 3-3-1-1 Positioning of Each Wireless Communications System



* Existing M2M connection are mainly 2G, 3G or 4G networks.

Figure 3-3-1-2 Examples Cases of the Utilization of LPWA

Sector		Country/Corporation etc.	Outline of cases (L: LoRa, S: Sigfox)
Japan	Verification Stage	7 corporations including Azbil Corporation and Japan IBM	Verification experiments relating to collection of data from gas and water meters in Fukuoka City began in July this year. Issues being identified in preparation for practical implementation [L]
		NTT Docomo, IT venture company Hata Pro	Verifying a system that monitors the operating status of the various facilities involved in a network connecting three water sources, eleven distribution reservoirs and the city office in Omachi City, Nagano Prefecture, in real time using LPWA [L]
		Hitachi Systems	Inspecting monitoring of manholes as part of a verification experiment towards the provision of crime prevention and safe solutions for the use of manholes, in cooperation with Tomisu, e-trust and Niigata City Water Authority [System unknown]
	Implementation Stage	Kyocera Communications System	Introduction of system that carries out remote temperature management of refrigerators where pizza dough is stored in a delivery pizza chain [S]

(Source) "Analysis of Industrial Structure in the 4th Industrial Revolution, and Surveys and Research into the Current State of and Outstanding Issues Relating to Developments Relating to IoT/AI," MIC (2017)

1. New Communications Technology Supporting the IoT

IoT devices and related applications have various uses cases and communications attributes. In particular, wireless devices are accompanied by a range of restrictive conditions due to the quantity of electricity they use and their radio characteristics, and as such it is difficult to meet all the needs that arise with a single communications technology or standard. For that reason, in order to meet such diverse needs, new communications technologies and standards have been conceived and developed in the past few years. Fig. 3-3-1-1 summarizes the various options, including existing technologies and standards, with a focus on their attributes.

(1) 5G

5G is the next-generation mobile communications system, which not only offers "super-high-speed" connection, but also the new attributes of "multiple connections" and "super-low delay." Its actualization is hotly anticipated as the foundation of the IoT in the ICT age. In Japan, the "5th Generation Mobile Communications Promotion Forum (5GMF)" was founded in September 2014.

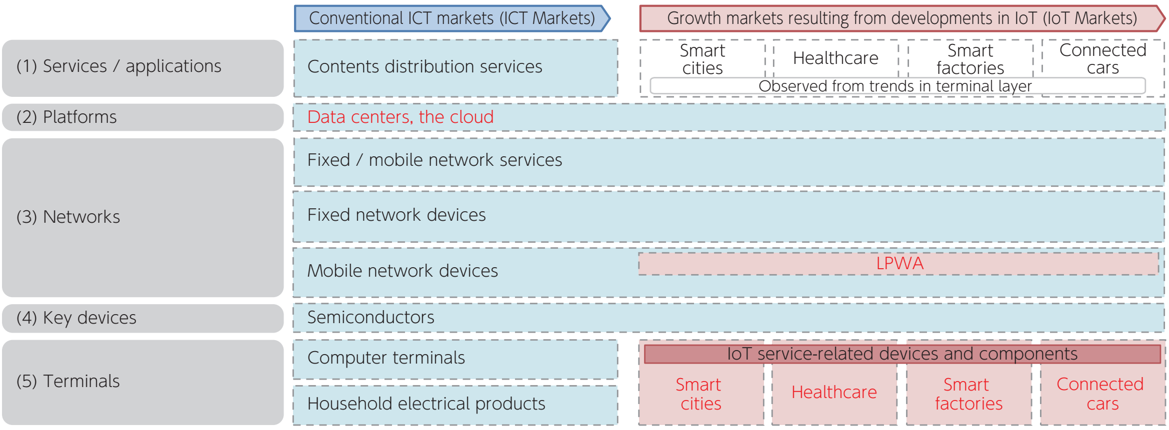
(2) LPWA

In the age of the IoT, it is necessary to respond to the communications needs of a wide variety of applications. In particular, the communications utilization and needs of industry require support for large-scale connections to multiple individual devices and lines, which may only transmit small amounts of data each. This needs to be provided at low cost, and available built into sensor devices for long-term use at low levels of energy consumption. Current development and provision based specifically on these requirements is underway, under the concept known as LPWA (Low Power Wide Area). LPWA communications speed is relatively slow, at between a few kbps to a few hundred kbps, but devices are extremely energy efficient – they can be used for between a few years to tens of years using regular batteries – and provide communications over large distances of between a few kilometers to several tens of kilometers.

2. Trends Observed in Layers

When focusing on the IoT and data distributions, which are factors in the realization of the 4th Industrial

Figure 3-3-2-1 Market Categorization Frameworks



(Source) Created based on "Global Competitiveness Indicators," MIC (February 2016)

Revolution, the four layers of "terminals/key devices," "networks," "platforms" and "services (data distribution)" are seen as related in the following ways.

"Services": Includes data connected via platform layer, and services provided by utilizing data.

"Platforms": In addition to the cloud, which provides a basic foundation for storage and processing of data, also includes authentification functions that identify terminals and individuals, and functions that enable various types of data to work together.

"Networks": Includes data transfer functions, configured from a range of fixed and mobile transmission lines.

"Terminals/Key devices": Includes sensors and actuators, as well as various other terminals for realizing IoT.

If ICT is considered to be the infrastructure for a wide range of industries and sectors, it is possible to consider the IoT as one format for the provision of ICT to various industries and sectors, where the necessary elements in each layer are connected vertically. Here, we define the target markets by layer (as above), and further, from the perspectives of conventional ICT markets (hereinafter "ICT markets") and markets growing as a result of developments in IoT (hereinafter "IoT markets"), to the extent that they can be seen and quantified, (Fig. 3-3-2-1), and divide them into the ICT market and the IoT market and consider their scale and growth, as well as new trends and examples, thus create an outlook of future changes in the new (broadly defined) ICT industry as a whole.

3. International Comparison of Progress Indicators in IoT

(1) Framework for Progress Indicators in IoT

Within the IoT society, groups of applications and services that can deliver new values are created, offering convenience, energy savings, business efficiency and other improvements to users. These added values are expected to dramatically improve standards of living, as well as reforming industrial structures, leading to a global restructuring of business and a transition in the source of value.

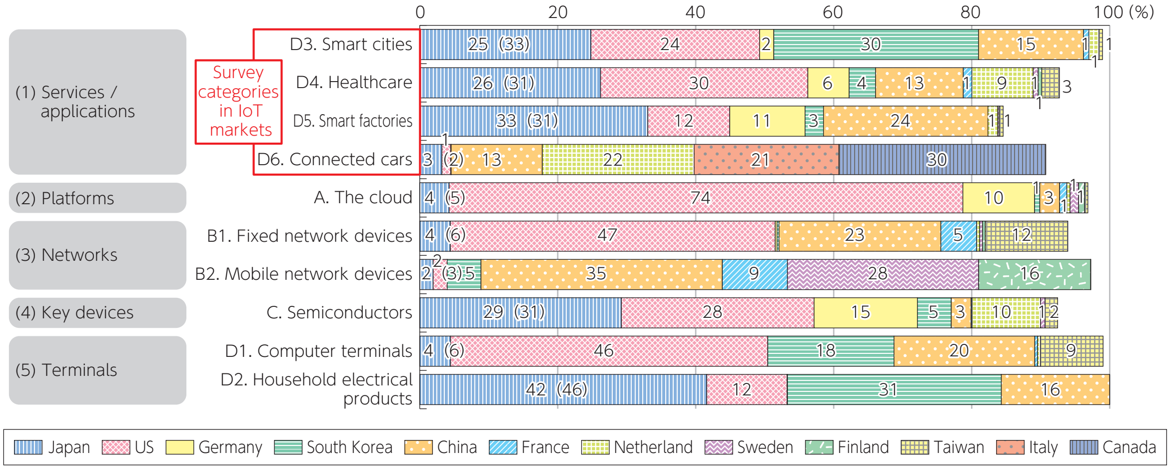
The Ministry of Internal Affairs and Communications measured changes in regional competitiveness, from market share and share of value of exports, between 2008 and 2015, and published these figures as "Indicators of Global Competitiveness in ICT." Given the background described above, however, it has now defined "Indicators of Global Competitiveness in IoT." These indicators are based on the conventional "Indicators of Global Competitiveness in ICT," but also (1) analyze the ICT industry by dividing it into "Growth markets resulting from developments in IoT (IoT Markets)" and "Conventional ICT markets (ICT Markets)," (2) introduce indicators relating to "Service and product competitiveness" as well as "Potential competitiveness" in the areas of research and development, and finance, etc., and (3) scores the main ten countries and regions in terms of their corporate competitiveness, and calculate overall rank.

(2) Comparison of Market Share between IoT Markets

Firstly let us take a look at the market share held by Japanese companies in various global markets. While Japan's market share is growing in categories related to IoT markets, it is also shrinking in categories related to ICT markets. A comparison of global market growth rates and Japanese market growth rates shows that the market share of Japanese companies is growing at a faster rate than the global market in categories related to IoT markets.

Looking at the market share of services and products held by companies in the main countries and regions, we can see that Japanese companies have achieved a certain level of share in categories related to the IoT markets. In comparison with 2013, Japanese companies' market share has increased in various sectors, notably "smart factories" and "connected cars (Figure 3-3-3-1)."

Figure 3-3-3-1 Market share, by category (2015)



(Source) Created based on "Global IoT Competitiveness Indicators," MIC (March 2017)

Section 4 Verification of Effect of ICT Investment Using Input-Output Table

1. Did the Digitization of Industry Lead to Economic Growth? – The Reason Japan's ICT Investment and ICT Human Resources Development has Fallen Behind –

(1) The Relationship between IT Investment / ICT Investment and Added Value

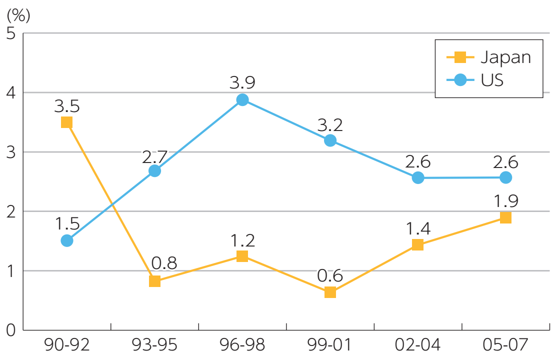
In this section, we look at the relationship between investment and added value. From the mid-1990s through to the mid-2000s, Japan implemented a certain level of investment in information technology, which contributed to economic growth as it built up in the form of information capital. At the same time, IT investment, the buildup of information capital, and economic growth were all lower than that in the US (Figure 3-4-1-1, Figure 3-4-1-2).

As has been pointed out in multiple incidences of prior research, and was mentioned in the White Paper Information and Communications Japan 2016, during the above period significant ICT investment and introduction was implemented in industries other than the ICT industry (logistics, services etc.) in the US, compared with which investment in ICT and input of ICT to industries other than the ICT industry in Japan was relatively low.

(2) The Reason ICT Investment and ICT Human Resources Development Fell Behind in Japan

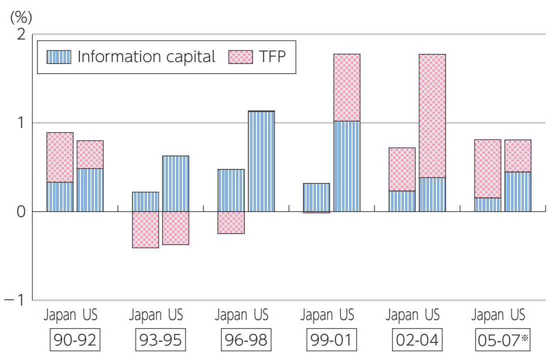
What are the reasons that ICT investment and ICT human resources development have fallen behind? Based on prior research, the following three points can be list-

Figure 3-4-1-1 Trend in real GDP growth rates in Japan and the United States during the 3rd Industrial Revolution[20]



(Source) Created from information in White Paper Information and Communications Japan 2012

Figure 3-4-1-2 Contribution of TFP and information capital to real growth rate in Japan and the United States during the 3rd Industrial Revolution[21]



(Source) Created from information in White Paper Information and Communications Japan 2012

[20] Data up to 2006 for Japan.

[21] Data up to 2006 for Japan.

ed.

(i) A lack of awareness that digitization leads to the creation of value

(ii) Funding restrictions, and a lack of maturity in BPO (Business Process Outsourcing) markets

(iii) A lack of broader Sense of investment (macroeconomic intangible asset investment, organizational reforms and human capital investment etc.) to accompany ICT investment.

In relation to the first point (a lack of awareness that digitization leads to the creation of value), there is a tendency in Japan to view ICT as a means to improve efficiency and reduce costs. When asked about the status of IoT introduction and future plans for introduction, broken down into processes and products, the facts that there was a greater focus on processes, and that, as mentioned below, a Japan Development Bank survey in 2016 showed a high proportion of respondents stating that the purpose of IoT investment was to “Reduce labor and improve productivity” also speak to this tendency.

In terms of the second point (funding restrictions), Fukao, Ikeuchi, Kim and Kwon (2015) state that in prior research outside of Japan, it is noted that larger companies and younger companies tend to adopt ICT more easily, and explore the ways in which the scale and age of a company affects ICT investment Japan, since the data shows that small companies and older companies make up a higher proportion of the economy than in other countries. They conclude that larger companies do use ICT at greater levels, but that there was no clear link between the age of a company and its use of ICT. The production coefficient is different for corporate scale and the age of the company, and smaller companies and younger companies have higher ICT marginal productivity; in other words, ICT investment has remained at a lower than optimum level. Furthermore, the authors say, certain obstacles are limiting the use of ICT within Japanese companies. Examples given of obstacles are funding restrictions, and a lack of maturity in BPO (Business Process Outsourcing) markets.

In regard to the third point, an indicator of a broader sense of investment (macroeconomic intangible asset investment, organizational reforms and human capital investment etc.) to accompany ICT investment is TFP (Total Factor Productivity). Based on Fig. 3-4-1-2 above, TFP was lower in Japan compared to the US, in particular between 1999 and 2004, by about 1% point per year, indicating that a broader sense of investment in Japan was insufficient compared to that in the US, and that economic growth equivalent to that in the US has not been achieved.

When considering a broader sense of investment (macroeconomic intangible asset investment), it is believed important to look at historical precedent. In the areas of electricity, automobiles and computers, which are examples of general-purpose technology, societies have undergone significant changes that were late in rolling out such technologies[22]. From a different perspective, during the period of change between old and new technologies, not only do old and new technologies exist together, but also other facilities, human resources, work flow, organizational structure and other various social structures continue for a while to be influenced by old technologies, and it can take between decades and several generations before the benefits of new technology begin to significantly improve productivity and realize economic growth. Furthermore, at times of decline in old technology, the economy has often suffered and unemployment risen, but in the medium- to long-term, new technologies lead to new industry and employment. General purpose technologies have never been widely accepted at their earliest stages, but it is important to learn from the fact that the utilization of general purpose technologies, including the accompanying reforms to organizational and social structures, has clearly led to economic growth only in regions and countries where it has led to improved productivity. In comparison with the time base for new technological change, it is clear from history that the response of human resources, organizational structures and social systems requires a longer time period, and that in order to improve productivity, measures are required, possibly through the introduction of IoT or AI, to improve the response speed of human resources, organizational structures and social systems.

Section 5 Comprehensive Analysis of the 4th Industrial Revolution

1. Data-driven Economic Growth

In order to create value and solve problems in an age where IoT/AI introduction and the utilization of data has become significant, it is necessary not only to learn the lesson from history that both ICT investment and a broader sense of investment is required, but also to consider the characteristics of data within the worlds of IoT and AI.

(1) ICT Investment and Broader Sense of Investment

ICT investment has moved from hard to soft and then

[22] Shinozaki (2014) comments on David analysis of the period when electrical technology was introduced to the US in the second industrial revolution between the 19th and 20th century, stating that the Central Power Plant was opened in New York in 1881, but that the rate of electricity use in manufacturing was still only 5% in 1899, and only 3% in households, and that it took a further 20 years for it to exceed 50%. He notes the swift increase in TFP use in manufacturing from the 1920s onwards, and notes that the dual structure of new and old technologies can be inefficient in areas such as human resources training and organizational management, and that from a different perspective, at the point at which old technology gives way to new technology, after a certain period of time, the introduction of new technology tends to result in overall increased productivity.

into services, and in order to connect ICT investment to economic growth a wide range of systems reforms are also required. Specifically, these include reforms to business processes and organizations, research and development and human resources development. These various reforms are often referred to as a "broader sense of investment" or "intangible assets" macroeconomically. Here, we look at ICT investment and a broader sense of investment ("intangible assets" macroeconomically) based on prior research.

The Japan Development Bank has implemented a survey[23] of facilities investment planning by large companies in the 60 years after the Second World War (hereinafter referred to as the "facilities survey"). The 2016 facilities survey includes factors that have led to increased IT investment. "Reduce labor and improve productivity," which was the most popular response, at around 50%, was followed by "Strengthening information security," at around 30%. At the same time, fewer than 10% of respondents selected "In order to utilize IoT and big data," indicating that IoT investment is low in priority. The Japan Development Bank typifies a broader sense of investment as a "General effort to achieve corporate growth, long-term survival and improvement of corporate value in the future" (Fig. 3-5-1-1).

We see a further tendency to include a broader sense of investment and intangible assets within GDP. SNA (system of national accounts) is used in estimation of GDP, and was first defined by the UN Statistical Commission in 1953, and this definition was revised in 1968, 1993 and 2008. Various countries use it as a standard for estimation of GDP. In the 2008SNA, intangible assets were made a larger part of GDP, and in Japan, 2008SNA was first applied as a new criteria of the GDP published in December 2016. Research and development is one of the points of the 2008SNA revisions, and the significant impact of this aspect is thought to indicate the importance of innovation. (Figure 3-5-1-2)

Within macroeconomics, Corrad, Hulten and Sichel's categorization is often quoted in regard to intangible assets. This separates intangible assets into computerized information, innovative property, and economic competencies.

Figure 3-5-1-2 Categorization of Intellectual Property Product in 2008SNA

Research and development
Mineral exploitation and evaluation
Computer software and databases
Entertainment, literary and artistic originals
Other intellectual products

(Source) United Nations Statistics Division
The System of National Accounts 2008 Annex3

The categorization of trends shown above includes "software/databases," "R&D (including IPR)," "human resources" and "organizational reforms." It is believed that can be broadly divided data-related elements and human resources and organizational elements they as.

Examples of companies that are said to be effectively analyzing data are thought to offer some useful suggestions when considering how to quantitatively analyze data and link it to added value and problem solving, while considering what reforms are needed in human resources and organizations.

It has become much easier in the past ten years or so to perform data set analysis by computer and yield output results, and in general people can now do it, but it is believed important to clarify the purpose of the analysis, and consider what theories are being posited and what type of data is being used, and to ensure that data is actually used for corporate decision-making for bringing about added value and solving problems.

In examples in which data analysis is said to have brought about results, we see trends towards optimization not only of business flow and organizational reforms, but rather of the overall optimization; the emergence of theories and data at the workplace level; positive feedback into data storage and problem solving, and finally its use in business-related decision-making.

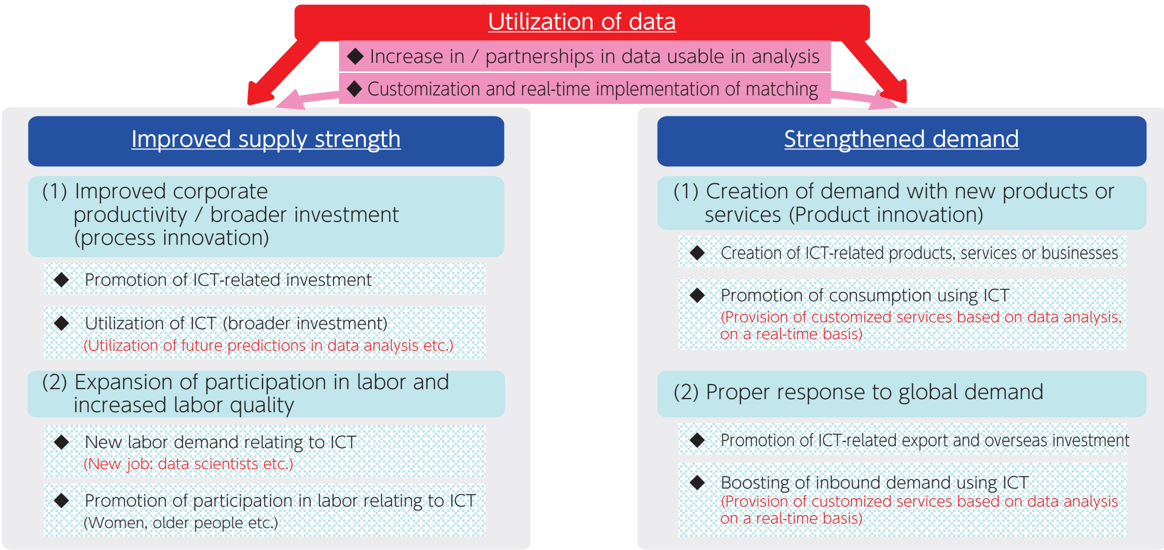
Figure 3-5-1-1 Categorization of Broader Sense of Investment by the Japan Development Bank

Scope	Category	Financial scale (year, corporation overall)	Characteristics contents
Narrower sense of investment / Broader sense of investment	(1) Domestic tangible fixed asset investment	(around 60 trillion yen)	Acquisition of fixed assets required for the maintenance/expansion of production/business activities.
Broader sense of investment	(2) Domestic intangible fixed asset investment	(around 10 trillion yen)	Acquisition of software, patents and trademarks etc.
Broader sense of investment	(3) International tangible fixed asset investment	(around 10 trillion yen)	Tangible fixed asset investment overseas.
Broader sense of investment	(4) M&A	(around 15 trillion yen)	Mergers and acquistions to expand into new business sectors to grow.
Broader sense of investment	(5) R&D costs	(around 13 trillion yen)	Research activities to develop new products and ensure future technological superiority.
Broader sense of investment	(6) Investment in human resources	(differs depending on definition)	Human resource development/training in order to improve overall corporate competitiveness.

(Source) "Outline of 2016 Survey of Facilities Investment Planning," Japan Development Bank (4th August 2016)

[23] Japan Development Bank "Outline of 2016 Survey of Facilities Investment Planning" (4th August 2016) http://www.dbj.jp/investigate/equip/national/pdf_all/201608_summary.pdf

Figure 3-5-1-3 Further Improved Supply Strength and Strengthened Demand through Data Utilization



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

(2) The Impact of Data Distribution and Utilization

Digital data is characterized by the following.

- It is easily reproduced (non-eliminative, non-competitive)
- It is instantly communicable and has almost zero marginal cost

Digital data has come to be used to a certain extent within information society, subsequent to the 3rd Industrial Revolution. The characteristics of data distribution in the 4th Industrial Revolution (Society5.0) include the elements of wider use of smartphones, the rollout of various sensors, the exponential growth in processing capability of computers (including AI), and the fact that data distribution and storage is increasing in both quantity and quality.

The establishment of cyber security is a prerequisite, but there is increasing potential for combinations and partnerships in the increased volume and number of types of data, and it is believed that this offers potential for creation of value and problem solving.

An old but also new problem with data analysis and AI is the determination of what variables (feature values) are used in analysis. Machine learning is a category of technology necessary for humans to select feature value. Between 2016 and 2017, however, it became possible for analysis that used to take data scientists several months to be implemented within a few hours, as a result of the software known as DataRobot, provided by DataRobot Inc., an American venture company. The software still requires feature values to be input by humans, but DataRobot then determines which feature values are effective, and since most of the trial and error procedures formerly implemented by data scientists are mechanized, the time required for analysis is expected to become much shorter, and the scope of analysis is expected to expand, in the situation of a shortage of data scientists.

Changes in data and data utilization have impacted economic growth and society. They have not only brought about changes on the supply side and the demand side, but also made it possible to match suppliers and consumers in real time, thereby improving productivity and enabling the effective utilization of resources and development of new services in ways that were not possible until now. It is believed that the matching of supply and demand is particularly effective in the broader sense of the service industry. (Figure 3-5-1-3)

The share held by tertiary industry is growing globally in many countries, and the economy is also becoming increasingly service-oriented. From a different perspective, in order to achieve economic growth it is necessary to improve productivity within the broader sense of the service industry, which accounts for a large market share.

Since many are intangible from the point of view of service, the role of digital data is considered to be significant in terms of matching supply and demand at the same time and in the same place.

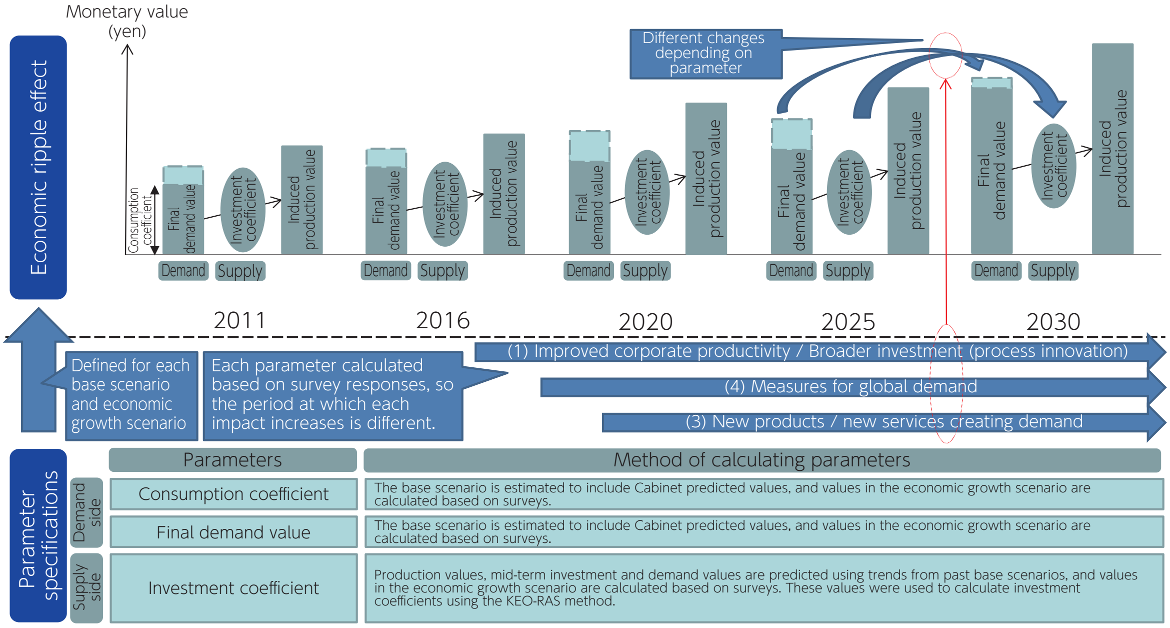
2. Japan in 2030 after adopting the IoT

In this section, we look at predicted values for various indicators including market scale between 2011 and 2030[24] (induced production value), real GDP and the number of people in the workforce[25] (induced labor value), and compare the base scenario based on economic predictions by the Cabinet for the medium- to long-term

[24] Industrial analysis tends to use the term "induced production value," but in consideration of general ease of understanding to the reader, we use "market scale" here. The "induced production value" used here is a real value.

[25] Industrial analysis tends to use the term "induced labor value," but in consideration of general ease of understanding to the reader, we use "number of people in the workforce" here.

Figure 3-5-2-1 Future Estimates of Economic Growth Resulting from IoT/AI Time base for estimates and scenario design



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

with a scenario for economic growth if the use of IoT and AI proceeds, in order to view the impact of the 4^{th} Industrial Revolution.

(1) Frame of Analysis

Estimates used an input-output table, in order to look at both the supply side and the demand side, and furthermore include the mutual dependency between the two and the ripple effect in analysis by industry.

The time bases for estimates were 2016, 2020, 2025 and 2030, and the predictive values indicators for market scale (induced production value), real GDP and the number of people in the workforce (induced labor value), give a comparison between the base scenario based on economic predictions by the Cabinet[26] for the medium- to long-term with a scenario for economic growth if the use of IoT and AI proceeds. (Figure 3-5-2-1)

The economic growth scenario envisages that the introduction of IoT/AI and corporate reforms, for example, process innovation and product innovation, may happen at different times.

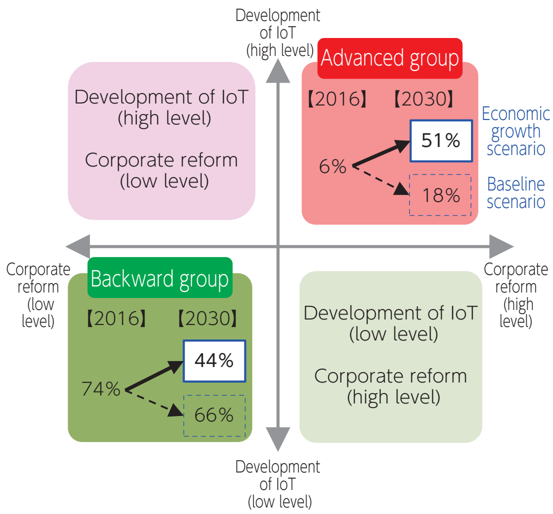
As noted above, both IoT/AI introduction and corporate reforms will be necessary for economic growth, and this simulation takes both into account. (Figure 3-5-2-2)

As part of the simulation, corporations were surveyed to assess the current and future level of IoT (rate of IoT solution introduction and IoT in products/services), and the level of corporate reform. Based on this, the proportion of corporations categorized to each of the base scenario and the economic growth scenario has been calculated.

In the base scenario, there is no change in the implementation of corporate reforms between 2016 and 2030, while the transition in proportion of IoT introduction was calculated based on values predicted for each year from the survey.

In the economic growth scenario, it was assumed that

Figure 3-5-2-2 Corporate classification (Development of IoT × Corporate reform)



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

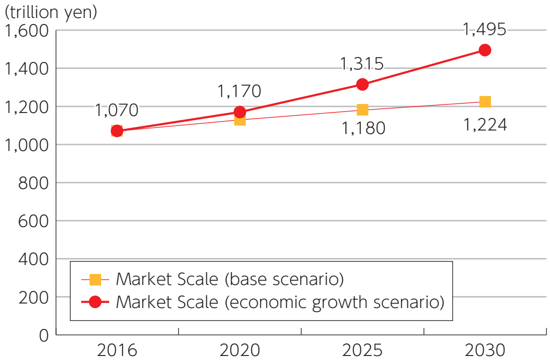
corporations responding that they faced non-fundamental obstacles to introducing IoT will have removed these obstacles and pressed ahead with IoT by 2030, and that IoT corporations will have made progress in implementing corporate reforms.

(2) Estimates of Market Scale and Real GDP

Based on the framework described to this point, estimates were performed of the extent of the impact of IoT and AI on economic growth, clarifying that in 2030, they will push real GDP 132 trillion yen. (Figure 3-5-2-3, 3-5-2-4)

In estimates, attention was paid not only to the primary but also the secondary ripple effect. (Figure 3-5-2-5) There are many intangible elements – service, contents and software – and even if demand increases in the fu-

Figure 3-5-2-3 The Impact of IoT/AI on Economic Growth through to 2030



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

ture the ripple effect will be limited, but labor input will result in a ripple effect on income. By looking at the ripple effect on income, it is possible to understand aspects of the impact of services, contents and software, and human resources as sources of added value. (Figure 3-5-2-6)

(3) Anticipated Raising of Floor in Labor Market

In Japan, compared to other countries, there is a swiftly declining birthrate and ageing population. The working-age population reached its peak in 1995, and the population as a whole peaked in 2008 and is now in decline. The Ministry of Internal Affairs and Communications' "National Census" gives the total population of Japan (including those whose age is unclear) as 127.09 million in 2015, with a working-age population (between 15 and 64 years) of 76.29 million. The population aged under 14 has been in decline continually since 1982, and it is clear that the falling birthrate has not been stopped.

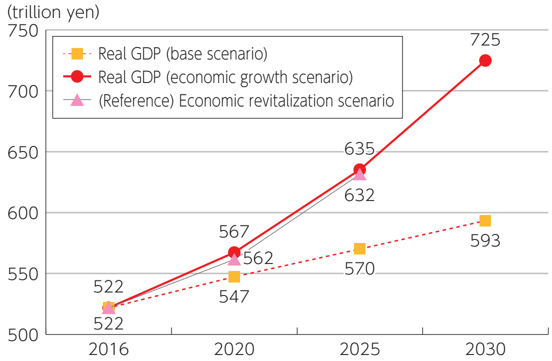
The declining birthrate, ageing population and accompanying decline on overall population have a negative impact on both the supply and the demand sides, and there is a possibility that they will also present obstacles to medium- to long-term economic growth in Japan.

In order to ensure sustainable economic growth against the background of a declining population, there needs to be wider participation in the labor force, and improved education and human resources development to improve the quality of labor, to thereby promote innovation and raise productivity.

Recently, the rate of unemployment has been maintained at a low level, and restrictions in the supply of labor have begun to cause problems. Promotion of wider participation in labor by women and older people, and improvements in quality of labor to increase productivity are likely to become more and more important.

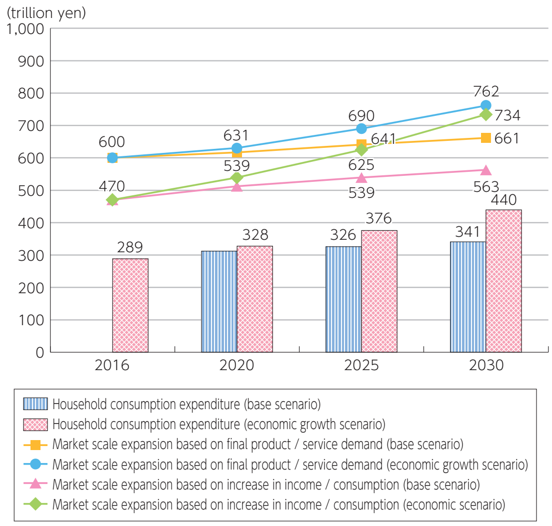
If investment in ICT, including the introduction of IoT and AI and the removal of factors that present obstacles, as well as corporate reforms in response to the age of data distribution (review of operation, organizational reforms, human resources development etc.) can be achieved, real GDP will be pushed up 132 trillion yen in 2030, and it is possible that sustained economic growth could be achieved despite a falling population.

Figure 3-5-2-4 The Impact of IoT/AI on Economic Growth through to 2030 (Real GDP)



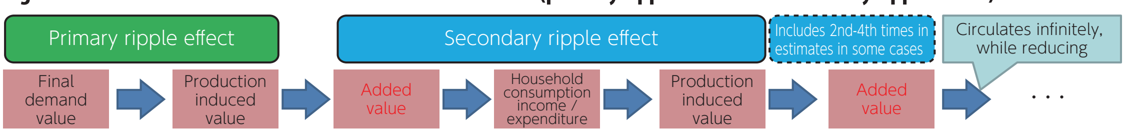
(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

Figure 3-5-2-6 Increase in Market Scale Resulting from Increased Income/Consumption



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

Figure 3-5-2-5 Estimated Inducement Effect from Income (primary ripple effect and secondary ripple effect)



(Source) "Survey Research into Various Issues Relating to the ICT Economy in the IoT Age," MIC (2017)

[26] Real GDP predicted value was estimated based on SNA 2016 actual value and Cabinet medium-term economic predictions for economic growth. Cabinet medium- and long-term economic predictions for economic growth are available to 2025, so predictions for 2026-2030 assume the same growth rate as 2025.

The economy is impacted by both supply and demand. As supply is reduced by the lack of labor caused by population decline, demand also falls due to a fall in income. It is anticipated that innovations such as IoT and AI will solve some of the problems caused by labor shortages through productivity improvement, and may increase individual income, thereby creating new demand.