FY2014
Summary of the White Paper on
Manufacturing Industries
(Monodzukuri)

June 2015

Ministry of Economy, Trade and industry (METI)
Ministry of Health, Labour and Welfare (MHLW)
Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Part I  Current Status and Challenges of Manufacturing Infrastructure Technology

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Outline of Chapter 1. Challenges that Japan’s Manufacturing Industry Faces and its Future

- Japan’s economy has been steadily on an upward trend, while the positive effects of Abenomics have been seen. Corporate earnings have improved mainly in the manufacturing industry, and also there is a growing movement towards raising wages, which is making continued progress toward a virtuous economic cycle. On the other hand, Japan’s current account surplus (calendar year-based) has shrunk for four consecutive years and recorded the smallest ever surplus. Looking at the breakdown, the trade deficit was the highest ever recorded, however, the balance on primary income, including overseas investment earnings, recorded the largest ever surplus. Accordingly, Japan’s manufacturing industry’s ways of earning are steadily shifting from earnings through exports to earnings from overseas.

(1) Recognition of the Current Status of Japan’s Manufacturing Industry

- While enterprise performance has progressively improved against the backdrop of Abenomics, and domestic capital investment is increasing also, it is important to further encourage investment.

(2) The Manufacturing Industry, Which Supports Japan’s Industrial Structure

- The manufacturing industry, which accounts for 20% of Japan’s GDP, creates new innovation and technology, and has a powerful ripple effect on other industries, is continuously important.
- The challenges are to examine the roles of domestic bases, and clarify areas for earning profits in Japan and overseas respectively, as well as developing various human resources and companies as the foundation of the manufacturing industry in Japan.

New Developments and Visions of the Future in the Manufacturing Industry – Manufacturing in a Data-Driven Society –

- While the manufacturing industry has also dramatically changed due to the progress in the IoT (Internet of Things), support for new business models in the manufacturing industry is an important challenge. Taking each country’s actions into account, including Industry 4.0, it is necessary to consider the future direction of Japan’s manufacturing industry.
<table>
<thead>
<tr>
<th>(1) The manufacturing industry as a field of good quality employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Although the manufacturing industry is said to be a field of good quality employment, the number of domestic employees and newly employed young persons has tended to decrease.</td>
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<table>
<thead>
<tr>
<th>(2) Roles which human resources for manufacturing have played in the manufacturing industry</th>
</tr>
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<tbody>
<tr>
<td>A survey shows that human resources for manufacturing (technicians and engineers) have performed important roles in companies and, consequently, their skilled techniques have become the source of strength for companies. In order for technicians to become fully independent, however, it takes from five to ten years, and even more time is needed to develop technicians with skilled techniques.</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>(3) Current status of securement and development of human resources in the manufacturing industry</th>
</tr>
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<tbody>
<tr>
<td>As for the actual status of the development of human resources and their capabilities at companies for which human resources for manufacturing have played important roles, various efforts are being made, including efforts for promoting the retention of human resources, such as improving the treatment of employees, and efforts for the purpose of developing human resources and their abilities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(4) Measures required to Foster and Secure Manufacturing Human Resources in order to support good quality employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meanwhile, as for education and training for human resources for manufacturing, there are issues concerning the time for development, the securement of young human resources, and the shortage of instructors. Therefore, it is necessary to demonstrate the attractiveness of manufacturing, to support the securement of human resources including the implementation of vocational training based on companies’ needs, to provide subsidies for the development of human resources inside companies, and to support companies, including through the utilization of the National Trade Skill Test.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(5) Future directions for Fostering and Securing Human Resources in the manufacturing industry, which is a field of good quality employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is necessary to maintain and expand the manufacturing industry, which is a field of a good quality employment, in the future through various policies</td>
</tr>
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</table>
### Outline of Chapter 3. Education, Research, and Development to Support the Foundations of Japan’s Manufacturing Industries

#### (1) Strategic Development of Scientific and Technological Human Resources in Manufacturing

- Scientific and technological innovation is an important pillar of the growth strategy of Japan. In order for Japan to continue growing and generating new value, it is important to develop creative human resources who support this innovation.
- In order to develop human resources who drive scientific and technological innovation, various efforts are being made, including improvements in the research environment for young researchers.
- In addition, in order to strengthen the fields of science and technology more than ever, the [Strategy for Development of Human Resources in Science and Technology](#) was established and released in March 2015. Industry, academia, and government will work together toward the qualitative enhancement and quantitative securement of human resources in science and technology.
- Each type of school, including universities (engineering schools), colleges of technology, specialized upper secondary schools, and specialized training colleges, has also been developing human resources for manufacturing through practical vocational training. Also, efforts for promoting the success of female researchers have been made.

#### (2) Enhancement of Japan’s Educational and Cultural Capacity to Foster Manufacturing Human Resources

- In order to develop human resources for manufacturing who will be responsible for the next generation, elementary schools, junior high schools, and high schools have made efforts including career and vocational education.
- In order to re-train adults, universities and other institutions are working with industry to assist in the re-training of young people, including the development and implementation of customized vocational and educational programs.
- Museums and other facilities have made efforts, including exhibits and learning support activities that are provided to pique students’ interest in manufacturing.

#### (3) Promotion of Research and Development to Enhance Industrial Strength

- Manufacturing technology has added new value to products, which has contributed to the improvement of the international competitiveness of the industries supporting the Japanese economy. Research and development for the most advanced measurement and analysis techniques and equipment, and the continuous development and shared use of the most advanced, large-scale research and development infrastructure have been promoted.
- The establishment of effective cooperative relations between universities, which are knowledge hubs, and companies contributes to the streamlining of manufacturing in Japan and the increasing of added value. The creation of revolutionary innovation and construction of innovation creation hubs utilizing regional resources have been promoted by making use of collaboration between industry, academia, and government.
1. Improvement of business performance in Japan’s manufacturing industry

- **Enterprise performance** in Japan’s manufacturing industry has steadily improved.
- It is important to **accelerate the virtuous economic cycle, including raising wages**, to extend it throughout Japan, as well as to **further encourage investment**.

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**Fig. 1: Changes in Business Conditions DI (Diffusion Index), Tankan Survey by the BOJ (by Size of Enterprise)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Large Enterprises Manufacturing</th>
<th>Small Enterprises Manufacturing</th>
<th>Large Enterprises Nonmanufacturing</th>
<th>Small Enterprises Nonmanufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>-30</td>
<td>10</td>
<td>-30</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>-20</td>
<td>10</td>
<td>-20</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>-10</td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

(Source) “Short-Term Economic Survey of Enterprises in Japan,” Bank of Japan

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**Fig. 2: Performance of Companies Listed on the First Section of the Tokyo Stock Exchange (Manufacturing Industry), in FY 2014**

(Remarks) As of May 18, 2015
(Source) Nikkei NEEDS

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**Fig. 3: Implementation Status of Returning Business Profits to Employees (by Size of Enterprise)**

<table>
<thead>
<tr>
<th>Size of Enterprise</th>
<th>Already implemented (%)</th>
<th>Planned (%)</th>
<th>Not planned (%)</th>
<th>Not sure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small and medium enterprises</td>
<td>50.3%</td>
<td>15.7%</td>
<td>23.2%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Large enterprises</td>
<td>55.8%</td>
<td>8.7%</td>
<td>25.7%</td>
<td>9.7%</td>
</tr>
</tbody>
</table>

(Source) Surveyed by METI (December 2014)
- Capital investment is currently picking up, but is still lower than the level before the Global Financial Crisis in 2008.
- The tax incentive to promote capital investment to improve productivity will end in FY 2016. Although it is for immediate full depreciation or a 5% tax deduction in FY 2015, the benefits will be reduced to 50% special depreciation or a 4% tax deduction in FY 2016. Consequently, prompt capital investment decisions are a key point so that capital investment will be complete in FY 2015.

[Fig. 1: Changes in Nominal Capital Investment]

[Column] Tax incentive to promote capital investment to improve productivity

- Koto Kyoto Co., Ltd., a company developing its agricultural business exclusively for the production of Kujo negi (Japanese green onions), introduced new, cutting-edge facilities, which can wash negi in a short time (the value of the investment is approximately 300 million yen), when setting up a new plant. It realized substantial improvement in productivity. Then, the company hired 20 new employees in connection with the investment, which contributed to creating employment in the local community.

(Area) Seasonally adjusted
(Source) “System of National Accounts,” Cabinet Office

A facility for washing negi
2. Shrinkage of the surplus in current accounts and changes in ways of earning

The current account surplus (calendar year-based) has continued to decrease for four consecutive years. The key contributors to the current account surplus are shifting from earnings through exports to earnings through investment, influenced by the emerging idea of optimally located global production (or optimal global local production).

- A trade surplus was recorded for the first time in 49 months due to the substantial decrease in the import value of crude oil in March 2015.
- The import price of crude oil is ending a decline. Therefore, its impact on the trade balance may be reduced during and after April 2015.

[Fig. 1: Breakdown of the Current Account Structure (2014)]

- Balance on primary income: Direct investment income, etc.
- Balance on secondary income: Official Development Assistance (ODA), etc.
- Surplus of 3.3 billion yen

[(Reference data) Breakdown of the Current Account Balance Structure (by fiscal year)]


(Remarks) Preliminary values are included in FY 2014.
The trade deficit was the highest ever recorded. While fuel imports are increasing and the surplus in the electronics industry is contracting, the major contributors to exports are transportation equipment and general machinery, and this is representative of Japan’s trade.
On the other hand, the balance on primary income recorded the largest ever surplus through the expansion of overseas direct investment. Against the background of overseas business expansion by Japanese companies, both the earnings from direct investment and the return of profits to Japan have increased.

### Fig. 1: Trends in Trade Balance

<table>
<thead>
<tr>
<th>Year</th>
<th>Trade Surplus (Trillion yen)</th>
<th>Trade Deficit (Trillion yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>9.4</td>
<td>-8.2</td>
</tr>
<tr>
<td>2005</td>
<td>13.1</td>
<td>-14.1</td>
</tr>
<tr>
<td>2010</td>
<td>13.6</td>
<td>-16.3</td>
</tr>
<tr>
<td>2011</td>
<td>12.3</td>
<td>-20.6</td>
</tr>
<tr>
<td>2012</td>
<td>12.7</td>
<td>-23.1</td>
</tr>
<tr>
<td>2013</td>
<td>13.5</td>
<td>-25.9</td>
</tr>
<tr>
<td>2014</td>
<td>13.9</td>
<td>-26.2</td>
</tr>
</tbody>
</table>

### Fig. 2: Trends in Balance on Primary Income

(Trillion yen) (%)

- Other investment earnings
- Portfolio investment earnings
- Direct investment earnings
- Compensation of employees
- Balance on primary income
- Percentage of direct investment earnings out of the balance on primary income (right axis)

### Fig. 3: Breakdown of Earnings from Overseas (Figures to Derive Direct Investment Earnings)

- Direct investment earnings +6.5 trillion yen
- Earnings from overseas reinvestment (+2.6 trillion yen)
- Profits returned to Japan (+5.6 trillion yen)
- Profits of foreign companies in Japan (+1.7 trillion yen)

### Profits of Japanese companies overseas (+8.2 trillion yen)

(Remarks) 1. “Overseas reinvestment” refers to the value of reinvested earnings (credit), which is listed as direct investment in the Balance of Payments Statistics.
2. Profits returned to Japan refers to the value of dividends and withdrawals (credit) from the income of quasi-corporations listed in the abovementioned Statistics.
3. Profits of foreign companies in Japan refers to the total value of reinvested earnings, dividends, and withdrawals (debit) from the income of quasi-corporations listed in the abovementioned Statistics.

(Source) “Balance of Payments Statistics,” Ministry of Finance

### Fig. 4: Trends in Return of Profits to Japan

Return of profits to Japan is trending upward.
The ratios of overseas capital investment, which had increased at an extremely rapid pace, has now leveled off. The value of exports is on an upward trend, and the quantity of exports shows signs of recovery. However, the idea of optimally located global production (or optimal global local production) has not fundamentally changed, and it is thought that the trend of overseas business expansion by Japanese companies will continue.

[Fig. 1: Change in Ratio of Overseas Capital Investment and Exchange Rates]

- Value of capital investment in overseas affiliates
  - (Total value of capital investment in overseas affiliates and domestic companies (x))

- Overseas capital investment ratio
  - [Original figures (dotted line)]
  - [Seasonally adjusted figures (solid line) “values”]

[Fig. 2: Change in Exports and Exchange Rates]

- Value of exports
  - (Japanese yen basis)
  - Continuing upward trend

- Exchange rate (right axis)
- Quantity of exports
  - Shows signs of recovery.

1) The value and quantity of exports are seasonally adjusted. The quantity of exports is seasonally adjusted by the Cabinet Office.
2) The Yen / US dollar rate is the average TTM for the month.
1. Importance of Manufacturing Industry in Japan’s Industrial Structure

- Japan’s manufacturing industry accounts for about 20% of Japan’s gross domestic product (GDP, based on added value). The manufacturing industry has a powerful ripple effect on other industries, and it exceeds 30% of the value of domestic production (corresponding to sales).
- The regions where the manufacturing industry is active have a high level of prefectural income. Thus, the manufacturing industry plays an important role not only in employment creation but also income improvement in communities.

### Table: Magnitude of Production Repercussions

<table>
<thead>
<tr>
<th>Industry</th>
<th>Magnitude of production repercussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>All industries</td>
<td>1.93</td>
</tr>
<tr>
<td>Manufacturing industry</td>
<td>2.13</td>
</tr>
<tr>
<td>Service industry</td>
<td>1.62</td>
</tr>
</tbody>
</table>

Remarks: The “magnitude of production repercussions” refers to coefficients which indicate the magnitude of the production repercussions on production in each industry when one unit of final demand for domestic products is generated.

Source: “2011 Input-Output Tables (Preliminary),” Ministry of Internal Affairs and Communications

[Fig. 1: Change in Distribution of Gross Domestic Product (Nominal) by Industry (2013)]

[Fig. 2: Magnitude of Production Repercussions]

[Fig. 3: Distribution of Domestic Production Value (Corresponding to Sales) by Industry]

[Fig. 4: Income from and Value of Manufactured Goods Shipments by Prefecture]
The manufacturing industry’s share of the GDP was 18.8% (in 2013) in Japan, which was higher than that in the United States, the United Kingdom, and France (just over 10%), but lower than that in China, the Republic of Korea (around 30%), and Germany (just over 20%).

In the last ten years, manufacturing’s share of the GDP has decreased not only in Japan but also in the United States and the United Kingdom, while Germany, which emphasizes the importance of the manufacturing industry, has maintained its proportion.

The manufacturing industry’s share of employment was 16.9% in Japan (in 2012), which had gradually declined throughout the 2000s. This percentage has declined in other countries too, and has especially sharply declined in the United Kingdom and France.

In light of the current situation, each country is not only providing products that are continuations of previous products, but also strengthening its efforts, for example, through Advanced Manufacturing in the United States and Industry 4.0 in Germany, to shift toward the next-generation manufacturing industry, with features including leading-edge development in advanced fields and the creation of new business models.
• It is important to address the so-called **sextuple whammy problems** in terms of strengthening locational competitiveness.

• While energy costs and the human resource aspects (workforce shortages) are still big problems, the yen’s extreme appreciation has been corrected, and progress in measures for effective corporate tax rates and economic partnership agreements have been made. Consequently, the sextuple whammy is now being resolved.

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**[Fig. 1: Matters Required in Terms of Improvement in the Business Environment, Etc.]**

(Percentage of companies with valid answers, %)

- Improvement in the tax system including reduction of corporate taxes: 57.3%
- Smooth shift of labor force to growth industries: 9.4%
- Improvement for stable energy supply system: 35.9%
- Stable exchange rate: 59.3%
- Deregulation in growth markets and the environmental field: 17.5%
- Promotion of trade liberalization: 6.8%
- Improvement of infrastructure related to the business environment such as transportation and communications: 7.9%
- Support for development of human resources with high expertise: 21.4%
- Supply of risk money: 2.0%
- Improvement of the environment to encourage industrial reorganization and business consolidation: 15.3%
- Investment of public funds in basic research: 11.9%
- Support for promotion of partnerships beyond business relations and capital frameworks: 8.8%
- Other: 2.0%
- Nothing in particular: 5.0%

(\(n=555\))

**[Fig. 2: International Standards of Effective Corporate Tax Rates]**

<table>
<thead>
<tr>
<th>Corporate tax rates</th>
<th>2000</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD</td>
<td>Approx. 34%</td>
<td>24.98%</td>
</tr>
<tr>
<td>Asia</td>
<td>Approx. 28%</td>
<td>22.17%</td>
</tr>
<tr>
<td>Japan (Standard tax rate)</td>
<td>Approx. 41%</td>
<td>34.62%→32.11%</td>
</tr>
<tr>
<td>Japan (Tax rate for Tokyo)</td>
<td>Approx. 42%</td>
<td>35.64%→33.06% (April 2015-)</td>
</tr>
</tbody>
</table>

Source: Prepared by METI based on KPMG’s “Corporate tax rates table”

**[Fig. 3: Trends in Electricity Rates for Industrial Sector]**

(Yen/kWh)

- Up by 28.4%

(95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13)

Source: Prepared based on the Federation of Electric Power Companies of Japan’s “Electricity Demand (Confirmed Report)” and statements of account from power companies
2. Roles of Domestic Bases in Response to Changes in the Business Environment

- In the financial plans for 2014, regarding the use for which the allocation of funds increased compared to the previous year, the amount for domestic capital investment was the highest at 52.6% of the total, followed by overseas capital investment at 26.3% and research and development at 25.4%. **Domestic investment is on an upward trend.**
- According to the results of a questionnaire, **13% of enterprises (approximately 100 enterprises in total) responded that they had relocated their production bases back to Japan** in the past two years. As for the reasons for returning production to Japan, some enterprises listed the **correction of the yen’s appreciation** and the **rise of overseas production costs**, but most answers were about issues with manufacturing overseas such as **quality and delivery time**.

![Fig. 1: Purposes for Which the Allocation of Funds is to Be Increased](image1)

![Fig. 3: Return of Production Back to Japan in the Past Two Years](image3)

![Fig. 2: Examples of New Domestic Investment](image2)

![Fig. 4: Reasons for Having Returned Production Back to Japan](image4)

**Company name**
- HORIBA, Ltd.  
  **Outline of investment and goals**
  - Construction of HORIBA BIWAKO E-HARBOR at its own plant site in Otsu City, Shiga Prefecture, which is the largest base for development and manufacturing in the Kosei area. The total amount invested is 10 billion yen.
  - The introduction of a new production methodology is expected to double the production capacity and shorten delivery time to one-third of what it was.

- Glory LTD.  
  **Outline of investment and goals**
  - Construction of a new factory building at the site of the Himeji headquarters of Glory LTD. (3 billion yen).
  - The purpose is to consolidate its bases for the development of manufacturing technologies in addition to its bases for manufacturing and assembling products.

**Source:** “Corporate Behavior Awareness Survey” (June 2014), Development Bank of Japan
Domestic production bases are regarded by many enterprises as bases whose roles are differentiated from those of overseas production bases, and play roles as bases for innovation, which generate new value through innovations such as new technologies and products, mother factories, which support production technology for transfer overseas and back up overseas factories, and flexible factories, which can flexibly adapt to production needs including large-item small-volume production and short-term production.

- Most of the following departments are listed as those to remain in Japan: planning and business management, R&D, and mother factories. Thus, the roles of domestic bases are being differentiated.

[Fig. 1: Roles of Domestic Production Bases]

- Bases whose roles are differentiated from those of overseas production bases
  - 62.1%
- Flexible factories, which can flexibly adapt to production needs including high-mix low-volume production and short-term production
  - 13.3%
- “Know-how bases” which produce key modules so as to prevent leakage of technology and know-how
  - 4.0%
- “Mother factories,” which support manufacturing, engineering for transfer overseas, and back up overseas factories
  - 32.1%
- Prototype development bases, for providing prototype development and maintaining a minimum of viable fundamental technology
  - 2.1%
- Human resource development bases, which provide personnel training and support the transfer of knowledge and skills
  - 2.1%
- Other
  - 3.0%
- Plan to downsize or close domestic bases
  - 4.8%
- Nothing more than one of the production bases
  - 33.0%

[Fig. 2: Departments that are mostly to remain in Japan]

- Planning and business management
  - 79.4%
- Research and Development (basics)
  - 59.4%
- Research and Development (applications/prototypes)
  - 49.9%
- Mother factories (production of core components, etc.)
  - 54.5%
- Mass production (high value-added products)
  - 27.0%
- Mass production (commodity items)
  - 7.6%
- Product planning
  - 22.3%
- Marketing
  - 9.5%
- Financing
  - 43.8%
- Other
  - 3.8%
- None in particular
  - 7.6%

Source: Survey by METI (December 2014)
Remarks: Questionnaire to enterprises whose production bases are located overseas

[Column] Oki Electric Industry Co., Ltd.

- Oki Data Corporation, a company belonging to the OKI Group, transferred the production of A3 monochrome printers for the Japanese market, which had been manufactured at a plant in Shenzhen, China, to its Fukushima plant, and established a policy under which Oki Data would continue to increase the domestic production ratio mainly of high value-added products.
Although there have been some cases of domestic investment and the return of production bases to Japan, the GDP in the manufacturing industry has continuously declined from its peak (around 114 trillion yen) in 1997, and has remained at around 90 trillion yen in recent years. This is mostly because the ratio of overseas local production has been continuously increasing, and the ratio of overseas local procurement has also risen while domestic demand has been falling.

Under such circumstances, in order for the manufacturing industry to fundamentally support Japan’s economic growth in the future, it is important to identify the areas that should earn profit overseas and as well as the areas that should remain in Japan. Then, the areas remaining in Japan should maintain and strengthen their competitiveness in exports, and those earning profit overseas should establish a cycle that creates innovation by returning the profit earned overseas back to Japan.

It will be necessary to conduct reviews and discussions in the future according to the current situation and the characteristics of each industrial sector.

![Fig. 1: Changes in GDP by Industry](image1)

![Fig. 2: Ratio of Japanese Enterprises Which Carry Out Overseas Local Production And Percentage of Local Production](image2)

![Fig. 3: Breakdown of Procurement by Overseas Affiliates](image3)
Separation Between Areas That Should Remain in Japan and Areas That Should Earn Profits Overseas (i) Automobile Industry

- **The automobile industry is based on local production for local consumption.** Thus, even though yearly demand in Japan has been stagnating at around five million units, brisk overseas demand has driven Japanese automobile manufacturers to correspondingly expand their overseas business, which has led to their overseas production being more than 60% of their total production. In these circumstances, the ratio of exports (percentage of units for export out of domestic production) has moderately decreased, but actually individual manufacturers’ situations have varied. For example, some manufacturers have tended toward local production for local consumption, and others have maintained a certain ratio between their domestic production and export production. Meanwhile, manufacturers have a common direction for the future: they will position their production bases in Japan as mother factories and continue production in Japan, from a strategic perspective.

- The target number for production lines is approximately 200,000 cars per factory. **As for regions where there is no local production base, optimal local production is conducted judging from the overall situation including costs, and production bases in neighboring countries have actively exported to them.**

### Toyota Motor Corporation

#### Domestic production has remained at a certain quantity.

#### Due to a stronger tendency toward local production for local consumption, the ratio of exports has substantially declined.

#### The overseas production ratio has increased, while the number of units produced domestically has decreased.

[An example of the return of overseas production back to Japan]

- **Nissan Motor Co., Ltd.:** The Rogue SUV for North America is now manufactured in North America. However, in response to increased demand in North America (around 100,000 units per year), exporting those manufactured in Japan is under consideration. In addition, assuming that the current exchange rate level and brisk market in North America will continue, it is also under consideration for production in Japan to increase by 200,000 units, to 1.1 million units by FY 2017.

Remarks: The number of units refers to the number of passenger cars (excluding commercial vehicles).

Source: Prepared based on the International Organization of Motor Vehicle Manufacturers’ data and Japan Automobile Manufacturers Association, Inc.’s data.
Petrochemical basic products produced by breaking down naphtha are not only raw materials for commodity items but also raw materials for high value-added functional chemicals for which Japan dominates the world market. Due to joint production, each raw material can be produced in a certain proportion.

Japan is exporting ethylene and its derivatives to China today, but in the future, it is possible that chemical products which are made from lower-priced materials in the U.S. or the Middle East may be delivered to China, which could make it harder for Japan to export ethylene and other such chemicals. It is also true that reducing the production of ethylene may result in a disruption of the supply of raw materials required for competitive functional chemicals.

In addition, taking a decrease in domestic demand into account, there is a possibility that the domestic production of ethylene will decrease from 6.1 million tons per year in 2012 to 4.7 million tons per year by 2020. However, because of the reasons mentioned above, it is considered necessary to keep domestic production at a certain volume.

In eight regions in Japan, industrial complexes own 13 ethylene crackers in total. One of them will stop operating by April 2016.
The aircraft industry in Japan is now growing even though its size is just over 1.5 trillion yen, or one tenth of that of the U.S.

It is both necessary to meet strict technical requirements and to overcome high initial costs, while the minimum production lot for a complete aircraft is small, which creates high barriers to entry into the market. On the other hand, because aircraft have a long life cycle and there are no significant changes once parts suppliers and their share are determined, the scheme to continue to export the components which are produced in Japan through making the most of Japanese high technology as well as skilled human resources will be continued.

In order to respond to an increase in world demand as well as for the new development of a complete aircraft, heavy industrial manufacturers are actively making capital investments. Thus, the aircraft industry and related businesses are expected to expand and grow.

Separation Between Areas That Should Remain in Japan and Areas That Should Earn Profits Overseas (iii) Aircraft Industry

- This industry has previously been regarded as parts suppliers for each area of airframes, engines, and equipment, but now the industry is trying to enter the market for complete aircraft with the Mitsubishi Regional Jet (MRJ), in addition to being the exclusive suppliers of carbon fiber composite materials, which are utilized in 50% of the structural materials in the airframe of the Boeing 787. The aircraft industry in Japan is now growing even though its size is just over 1.5 trillion yen, or one tenth of that of the U.S.

- It is both necessary to meet strict technical requirements and to overcome high initial costs, while the minimum production lot for a complete aircraft is small, which creates high barriers to entry into the market. On the other hand, because aircraft have a long life cycle and there are no significant changes once parts suppliers and their share are determined, the scheme to continue to export the components which are produced in Japan through making the most of Japanese high technology as well as skilled human resources will be continued.

- In order to respond to an increase in world demand as well as for the new development of a complete aircraft, heavy industrial manufacturers are actively making capital investments. Thus, the aircraft industry and related businesses are expected to expand and grow.

[Fig. 1: Share of the Airframe of the Boeing 787]

Source: Japan Aircraft Development Corporation

[Fig. 2: Trends in the Value of Production of Aircraft]

Source: "(Revised) Forecast Value of Production, Exports and Orders of Aircraft for FY 2014" (August 2014), Society of Japanese Aerospace Companies

[Column] Invigoration of the Aircraft MRO Business

- Because it is necessary to secure a high level of safety in aircraft for the long term, the MRO (Maintenance, Repair and Overhaul for aircraft) business is important for airline companies, and also is an important, long-term source of profits for manufacturers of finished goods such as engines and parts for equipment through parts replacement.

- Along with the development of the national passenger airplane MRJ, a new MRO base will be established near Naha Airport. The formation of a competitive MRO business in Japan will contribute to the expansion of business and feedback for research and development.
In order to strengthen the manufacturing industry’s earning power, it is necessary to improve technologies through the enhancement of research and development (R&D) bases so as to continue providing the seeds of innovation. Many R&D bases have tended to remain in Japan, while production bases overseas have been expanding. As for the R&D expenses for the Japanese manufacturing industry, they have decreased from 12.2 trillion yen in 2007 to 10.7 trillion yen in 2012, and decreased especially sharply for information and communications equipment as well as for electronic parts and related items. It is important for the Japanese manufacturing industry to improve the attractiveness of its R&D bases.

<table>
<thead>
<tr>
<th>FY</th>
<th>Number of bases in Japan</th>
<th>Number of bases overseas</th>
<th>Ratio of bases in Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2009</td>
<td>6,368</td>
<td>220</td>
<td>96.7%</td>
</tr>
<tr>
<td>FY 2010</td>
<td>6,563</td>
<td>242</td>
<td>96.4%</td>
</tr>
<tr>
<td>FY 2011</td>
<td>6,665</td>
<td>231</td>
<td>96.7%</td>
</tr>
<tr>
<td>FY 2012</td>
<td>6,682</td>
<td>244</td>
<td>96.5%</td>
</tr>
</tbody>
</table>


[Column] Regulatory Reform in Regenerative Medicine Has Improved the Attractiveness of R&D Bases

- The Pharmaceuticals, Medical Devices, and Other Therapeutic Products Act (the former Pharmaceutical Affairs Law) and the Act on the Safety of Regenerative Medicine were enacted in November 2014. This allowed Japan to become the first country in the world to realize a swift approval system for regenerative medicine.

- In Japan, the time required for obtaining approval from the authorities, which used to be some seven years (same as in Europe and the U.S.), is expected to be significantly reduced to only two or three years at the earliest for commercial sales to start. The number of Japanese and foreign enterprises that are considering conducting clinical research on regenerative medicine products in Japan or considering entering the Japanese market is increasing.
3. Maintaining and Strengthening Domestic Production Bases

- Human resources for manufacturing, who support the manufacturing industry, have decreased in many kinds of businesses. To prepare for the possibility of a shortage of human resources, many enterprises are working on making use of elderly personnel and veteran personnel as well as women.
- While the way to earn profits is changing in the manufacturing industry, those who are engaged in manufacturing departments have decreased, but those in research and development departments have increased. Consequently, there has been a change in what kind of human resources are in demand as well.

[Fig. 1: Trends in the Productive-Age Population in Japan]

[Fig. 2: Efforts Taking the Shortage of Personnel into Account]

[Fig. 3: Trends in Working Population by Department in the Manufacturing Industry]

[Column] Gunma Monozukuri Kaizen InstructorSchool

- In collaboration with the University of Tokyo, Gunma Prefecture founded Gunma Monozukuri Kaizen Instructor School for training retired personnel to work on kaizen (improvement) activities at manufacturing sites, for the first time in Japan, in 2010.
- The school has produced more than 80 persons who have completed training so far. The retired personnel who have completed training are dispatched to small and medium enterprises (SMEs) to guide their kaizen activities. Many SMEs have achieved successful outcomes. This is a model example of working on kaizen activities through regional SMEs utilizing retired personnel.
The female employment rate is significantly lower than that for males in every age group in the manufacturing industry. In addition, the number of enterprises which did not hire any new female graduates exceeded half of the companies, which has generated a strong dependency on gender even at the hiring stage.

As not much progress in female employment in the manufacturing industry has been made compared to that in other industries, it is considered necessary to accelerate efforts for promoting the provision to women of more opportunities to play important, active roles, such as hiring women and appointing female employees to executive posts.

![Fig. 1: Employment Ratio by Age Group in Manufacturing and Nonmanufacturing Industries](image1)

### (Manufacturing)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 24 years old</td>
<td>20.7</td>
<td>7.6</td>
</tr>
<tr>
<td>25 to 29 years old</td>
<td>20.5</td>
<td>7.6</td>
</tr>
<tr>
<td>30 to 34 years old</td>
<td>20.0</td>
<td>8.3</td>
</tr>
<tr>
<td>35 to 39 years old</td>
<td>20.9</td>
<td>9.5</td>
</tr>
<tr>
<td>40 to 44 years old</td>
<td>21.8</td>
<td>9.2</td>
</tr>
<tr>
<td>45 to 49 years old</td>
<td>19.8</td>
<td>8.8</td>
</tr>
<tr>
<td>50 to 54 years old</td>
<td>17.3</td>
<td>8.0</td>
</tr>
<tr>
<td>55 to 59 years old</td>
<td>12.1</td>
<td>5.8</td>
</tr>
<tr>
<td>60 to 64 years old</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>65 years old and over</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

![Fig. 2: Ratio of Women among New Graduates Hired](image2)

### (Nonmanufacturing)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical, health care and welfare</td>
<td>16.8</td>
<td>25.8</td>
</tr>
<tr>
<td>Accommodations, eating and drinking services</td>
<td>6.7</td>
<td>25.8</td>
</tr>
<tr>
<td>Finance and insurance</td>
<td>11.8</td>
<td>25.8</td>
</tr>
<tr>
<td>Wholesale and retail trade</td>
<td>38.3</td>
<td>25.8</td>
</tr>
<tr>
<td>Transport and postal activities</td>
<td>51.8</td>
<td>25.8</td>
</tr>
<tr>
<td>Information and communications</td>
<td>28.1</td>
<td>25.8</td>
</tr>
<tr>
<td>Construction</td>
<td>73.1</td>
<td>25.8</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>54.3</td>
<td>25.8</td>
</tr>
</tbody>
</table>

Source: Basic Survey of Gender Equality in Employment Management (FY 2010)

### [Column] Active recruitment of various human resources at JFE Holdings, Inc.

- In order to link women’s power to economic vitalization, METI has bestowed the “Nadeshiko Brand” designation since FY 2012.
- JFE Holdings, Inc. was listed in FY 2013 and FY 2014, for two consecutive years, since the efforts of each company in the group were well appreciated.
- JFE Steel Corporation, which operates an iron and steel business, has driven active recruitment of various human resources, including women and foreign people. New female graduates hired, consequently, account for 10% of the total of the new graduates hired.
- It set up the Diversity Promotion Section in 2012, and introduced systems for supporting childbirth and childcare. In addition, the company started hiring women as blue collar workers for its steelworks, and has been continuously improving the working environment.

Source: “Labour Force Survey,” Ministry of Internal Affairs and Communications
Mid-ranking companies and SMEs play important roles in regional economies. For example, they create employment in communities, there is a high percentage of enterprises that do sourcing within the same prefecture, and they conduct business that is well rooted in the communities.

It is expected that many enterprises will grow to become Global Niche Top Companies and earn high profits in overseas markets.

Mid-ranking companies are defined as enterprises with 100 or more but less than 1,000 regular employees.

---

**TSUDAKOMA Corp. <Kanazawa City, Ishikawa Prefecture>**

- Tsudakoma’s staple products, jet looms (textile machinery), which are produced by only a few companies in advanced nations, are leading the industry with cutting-edge technologies, including high-speed operation that weaves more than 1,000 threads a minute.

- Their jet looms are widely used in the textile industry, for products ranging from luxury brand clothing to industrial material, all over the world. They have already been exported to more than 60 countries, and overseas sales account for 90% of their total sales.

---

*What is the Global Niche Top Companies Selection 100?*

METI selected outstanding enterprises that have maintained both a high global market share, mainly for exports, and profitability with their competitive products and technologies in particular areas, as the "Global Niche Top Companies Selection 100" in FY 2013.
For mid-ranking companies (*), which are expected to play important roles, the whole Government, led by the Cabinet Secretariat, has banded together to formulate a policy package for regional employment creation, ranging from fostering and securing of human resources to the development and production of products through the internationalization of business activities.

In order to discover and support mid-ranking companies which have great potential to be Global Niche Top Companies, this policy package plays major roles, including support for research and development, development of international sales channels, facilitating business succession, and support in the field of intellectual property.

* Enterprises whose sales come to 100 billion yen or less are defined as mid-ranking companies.
In the field of Monodzukuri, the environment has advanced so that it has become easier to start a business (spread of digital fabrication machines including 3D printers, and improvements in manufacturing bases including DMM.make AKIBA).

Accordingly, it is necessary to form a sustainable ecosystem which will create Monodzukuri ventures.

**[Column] DMM.make AKIBA, the unprecedented greatest base in the world**
- The production facilities, which cost 500 million yen in total, including 3D printers and machine tools, are able to mass produce up to around 100 units per lot.
- ABBALab, a seed accelerator, provides funds and know-how, and Cerevo Inc., a leading pioneer among manufacturing ventures, plays the role of a mentor, which can lead to ventures being developed.

**[Column] exiii Inc., for low-cost artificial arms for the world**
- A power-saving artificial arm is now under development, while receiving ABBALab’s support. By decreasing the number of motors in it and utilizing 3D printers, exii Inc. is aiming to achieve a lower price for the power-saving artificial arm, while previous products were more than 1 million yen.
Section 3. New Developments and Visions of the Future in the Manufacturing Industry

1. Manufacturing industry changing in a data-driven society

- Rapid technological innovation in IT is increasing the amount of accumulated data and expanding the range of applications for data. New added value is being produced in a cycle of data acquisition, analysis, and processing, changing competing areas in various fields.
- Meanwhile, the utilization of IT in the manufacturing industry in Japan is behind that in other countries. For example, the proactive and practical use of big data in Japan pales in comparison with that in the U.S. The use of IT has not progressed in the manufacturing industry in Japan, because significantly more IT experts work for IT service providers in Japan than in the U.S.

[Fig. 2] Survey on Use of Big Data

[Fig. 1] New Business Cycle with the IoT and Big Data

[Fig. 3] Japan-U.S. Comparison of Distribution of IT Experts
- The **Internet of Things (IoT)**, which organizes all things using data and connects them to the Internet, is actualized by sensor technology, battery technology, the miniaturization and speeding up of data processors, and also by the spreading of cloud technology that accumulates huge amounts of data.

- The **business models in the manufacturing industry are changing** through the use of IT for more than just streamlining production.

[Examples of the utilization of IT in the manufacturing industry (1)]

**[Column: Streamlining maintenance by remote monitoring of products at Eau de Vie Corporation]**
- Eau de Vie, which manufactures, sells, and maintains drinking water vending machines, remotely monitors the operational statuses of the machines through FOMA modules installed in the vending machines, which are installed in supermarkets and other locations.
- It has achieved an increase in its vending machine operation rate, improvement in customer satisfaction, and labor savings on maintenance. Consequently, its business can now also be expanded.

**[Column: Visualizing production lines at OMRON Corporation]**
- OMRON collects data from each device in its production lines, and analyzes the data through its own controller named Sysmac. It visualizes inefficiency in production lines.

**[Column: Systemizing know-how of expert designers at LIXIL Corporation]**
- LIXIL has launched Development Design NAVI, which visualizes various kinds of know-how that have been acquired by veteran designers and have become tacit knowledge and manages the know-how in a consolidated manner with IT.

- Now, it is possible to efficiently learn how to make designs for similar products and learn about design know-how from the past, which contributes to shorter design periods and the development of young designers.

**[Column: Streamlining of shipping operations by predicting customers’ orders at SUNCO INDUSTRIES CO., LTD]**
- SUNCO INDUSTRIES, which is a specialized wholesaler of screws, analyzes patterns in customers’ orders to deal with an increase in the number of types of screws (total 710,000 types) that they need to handle.

- It analyzes “tendencies” in orders to predict the timing of final orders by each customer and to streamline packing and shipping operations.
- It has resulted in the reduction of overtime working hours by half and the number of missing items by 40%, as well as an increase in sales of 30%.

<table>
<thead>
<tr>
<th>Examples of the utilization of IT in the manufacturing industry (1)]</th>
<th>Improvement status (reference/comparison times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total overtime working hours for the entire company</td>
<td>Down from 4,200 hours per month to 2,100 hours (comparison between after installation in September 2014 and one year prior to installation)</td>
</tr>
<tr>
<td>Number of items dealt with by one person in charge</td>
<td>Up by 28% (comparison of FY 2014 with FY 2011)</td>
</tr>
<tr>
<td>Daily sales</td>
<td>Up by 31% (comparison of FY 2014 with FY 2011)</td>
</tr>
<tr>
<td>Number of missing items</td>
<td>Down by 44% (comparison of FY 2014 with FY 2011)</td>
</tr>
<tr>
<td>Days in inventory</td>
<td>Down by 6% (comparison of FY 2014 with FY 2011)</td>
</tr>
</tbody>
</table>
Even though the manufacturing industry is changing through the IoT as mentioned above, in the manufacturing industry in Japan, in which competitiveness has been maintained by improving hardware technology through “craftsmen’s techniques” and “coordination” at manufacturing sites, cases of enhancement of added value and differentiation through the utilization of the IoT are fewer than those in Europe and the U.S., and in particular there are actually no providers of versatile platforms.

Japanese companies should also proactively use the IoT and enjoy its merits.
2. Trends in Europe and the U.S.

- Germany is promoting Industry 4.0 as a measure for stimulating the manufacturing industry utilizing the IoT.
- The country aims to make smart factories, which flexibly manufacture products to meet market needs by internally “connecting” inside companies and factories, and also to optimize the manufacturing industry in Germany as a whole by connecting companies by overcoming the barriers between them.
- The country aims to fundamentally reform manufacturing from the conventional production system, which has been streamlining production and optimizing the supply chain from the bottom up starting at manufacturing sites, to the new system which optimizes the entire system from the top down.

[Fig. 1: Industry 4.0 (the fourth industrial revolution)]

[Fig. 2-1: Conceptual diagram of manufacturing systems in Industry 4.0 (1)]

[Conceptual diagram of a manufacturing system]

- First industrial revolution
  Automation with steam engines
  (Latter part of the 18th century)
- Second industrial revolution
  Utilization of electric power
  (Early 20th century)
- Third industrial revolution
  Automation with computers
  (Since the 1980s)
- Fourth industrial revolution
  Autonomization through cyber-physical systems (IoT)

[Fig. 2-2: Conceptual diagram of manufacturing systems in Industry 4.0 (ii)]

(column: Hanover Messe)

- Hanover Messe is the world biggest international trade fair for industrial technology, which is held annually in Germany. The fair functions as a place where governments, companies, and research and development institutions demonstrate their efforts related to Industry 4.0 and compete.
- Industry 4.0 could be a threat, not because of the technological aspect but because of the fact that industry, government, and academia share the aim of “connecting” and are making steady progress.
In the U.S., GE leads the promotion of the Industrial Internet.

Data on operational status acquired through sensors installed in products such as aircraft engines is utilized for streamlining machine operation and for predictive maintenance.

Data from machines made by other companies can also be acquired by installing data analysis applications that are sold externally. There is the possibility that business models may be advanced by collecting data from around the world.

Behind the advancement of the manufacturing industry through the utilization of the IoT, there is also competition for acquiring greater added value between IT companies including Google.

[Fig. 1: An example of the Industrial Internet]

[Fig. 2: Overview of competition for added value through IT and monodzukuri]

[Fig. 3: GE’s “Predix” Data analysis application]
3. Direction of the Manufacturing Industry of Japan in an IoT Society

- Japan, which is the greatest robotics superpower in the world, proclaimed that it will lead the world with the robots of the IoT era and realize a robot revolution in Japan’s Robot Strategy compiled by the Robot Revolution Realization Council based on the recognition that the IoT has significantly changed the rules of competition in the manufacturing industry.
- Japan founded the Robot Revolution Initiative Council as a promoting organization to realize the robot revolution. The government, industry, and academia will also consider the direction of the manufacturing industry in an IoT society.

Concrete visions of the robot revolution (1)

1. Making Japan a showcase for state-of-the-art robots for the world − Spreading robots to every corner of daily life −

Designating the next five years as a time for focused implementation for the robot revolution:
- The public and private sectors will invest a total of 100 billion yen in projects related to robots.
- The market size for robots will increase to 2.4 trillion yen (per year). (Currently 600 billion yen)
- New demonstration sites for robots will be established in Fukushima. (Establishing demonstration areas for flying robots and disaster robots is expected to lead to the Innovation Coast Scheme.)

Concrete visions of the robot revolution (2)

2. Establishment of a global strategy/system for robots, taking trends in the IoT (Internet of Things) throughout the world into serious consideration

Strategies in Europe and the U.S.

U.S.: Cloud computing (e.g. Google)
- Getting added value through use of big data

Germany: Industry 4.0 (e.g. Siemens)
- Leading standardization for connecting production machines

Japan's Strategies − The key is securing a position not as a subcontractor for Europe and the U.S. by using Japan’s strengths (robots) −

Strategy I Winning the race for global standards for common infrastructure (such as operating systems) for robots in manufacturing sites, where Japan has advantages
- Utilizing robots and accumulating data (for big data) as a front-runner in various fields such as nursing care and infrastructure

Strategy II Strengthening artificial intelligence (AI) technology that creates wealth from accumulated data. Aiming for world-class level
- (e.g. on the actual use of nursing care sites, data on the deterioration of infrastructure over time)

Strategy III Council based on the recognition that the strengthening of global competitiveness creates wealth from robots
- Actively involving a total of more than 1,000 companies, universities, and research institutions
- Also involving core companies in Europe and the U.S.

Three pillars for realizing the revolution

(i) Becoming a global base for robot innovation
- (e.g. small and medium enterprises, agriculture, nursing and medical care, and infrastructure)

(ii) The society with the best and most proactive use of robots in the world
- Realizing a society in which robots create new added value through the resolution of social problems and the strengthening of global competitiveness
- (Making robots able to use big data, networks, and artificial intelligence being integrated with IT)

What is the Robot Revolution?

(i) Dramatic changes in robots (“Autonomizing,” “transforming into information terminal devices,” and “networking”)
- Turning automobiles, household appliances, mobile phones, and even housing into robots

(ii) Utilizing robots on actual manufacturing sites as well as in various situations in daily life

(iii) Realizing a society in which robots create new added value through the resolution of social problems and the strengthening of global competitiveness

Toward realization of the robot revolution
In the Robot Revolution Initiative Council, working groups are to be established, and the government, industry, and academia will consider the topics below and aim in the direction of standardization and open systems.

In any case, the most important matters for the manufacturing industry in an IoT society are to understand the merits of the use of IT and the IoT and to change directions drastically through tight cooperation between the government, academia, and industry.

(i) Realization of the merits of connecting
(a) Optimizing connections between processes (Division of processes between design, development, and manufacturing)
(b) Optimizing the insides of factories (Incompatible communication protocols)
(c) Optimizing the insides of companies (Insufficient coordination between control systems and IT)
(d) Optimizing relations between companies (Lack of efforts beyond individual optimization)

(a) Promoting the utilization of PLM (Product Lifecycle Management) tools by sharing the merits of their introduction
Considering Japanese-style PLM packages
(b) Opening telecommunications standards to the public
Using open interfaces
(c) Developing system integrators who can work with both control systems and IT
Using open interfaces
Keep in mind: Securing cybersecurity
(d) Identifying areas of cooperation and areas of competition
Creating precedents
Keep in mind: Securing cybersecurity

(ii) Creating added value with the use of data
(a) Using data inside of companies (Delay in use of data)
(b) Sharing data between companies (Lack of efforts beyond individual optimization)

(a) Clarifying the purposes of investment in use of data
Establishing necessary guidelines such as those on the treatment of proprietary rights to data
Reforming regulations (e.g. making industrial safety intelligent)
(b) Identifying areas of cooperation and areas of competition
Creating precedents
Establishing public infrastructure to accumulate data
Improving the fluidity of data through mechanisms for trading data

[Column: A plant monitoring system using big data]
◆ The Chugoku Electric Power Co., Inc. installed NEC’s Failure Sign Monitoring System in the Shimane Nuclear Power Plant Unit 2. The company measured the correlations between sensors, which were installed in large quantities.
◆ The system automatically detects unusual behaviors and identifies abnormalities in the facility before they lead to failure. Some cases were reported in which problems were detected more than seven hours earlier than they would have been using conventional means.

[Column: Japanese “linked factories” Industrial Value Chain Initiative]
◆ Led by Professor Yasuyuki Nishioka of Hosei University, a consortium with 22 private companies as advocates was established.
◆ Multiple companies cooperate and aim to establish models of “linked factories,” by integrating IT and manufacturing.
◆ Concentrating companies’ own resources on their own areas of expertise by eliminating in-house production policies and efficiently procuring common parts from outside. Therefore, it is essential to identify areas of cooperation and areas of competition.
◆ The consortium has a policy of collaborating with the Robot Revolution Initiative Council.
The manufacturing industry is said to be a field of good quality employment because it encompasses an extremely wide range of business activities and characteristics, including related local companies, a high employment capacity, and job security in terms of wages, regular employment rate, length of service, turnover rate, and other factors (Fig. 2-1).

However, severe business conditions have continued for an extended period due to intensified international competition, and the number of employees and newly employed young persons in the manufacturing industry in Japan has tended to decrease amidst these persistent headwinds (Fig. 2-2).

[Fig. 2-1] Average of length of service and turnover rate

[Fig. 2-2: Number of Employees Engaged in Manufacturing]
The manufacturing industry has made efforts to secure its survival, such as the “reduction of costs by continuing small improvements” (51.4%) and “support for selling single items and small lots” (44.2%) in the midst of the current severe pressures mentioned previously (Fig. 2-3).

Also, among the companies that have made efforts for survival, 89.7% of them (technicians and engineers account for 49.3% and 23.3% respectively) answered yes to a question about whether human resources in manufacturing perform important roles in the process of producing and providing products/services, which indicates that human resources for manufacturing have performed important roles (Fig. 2-4).

2. Responses and Roles of human resources for manufacturing

[Fig. 2-3] Efforts that companies have made for their survival (multiple answers)

[Fig. 2-4] Human resources for manufacturing that have played important roles in terms of manufacturing products or providing services

- 33.8% of manufacturing companies listed “Having high-skill techniques” as one of their strengths (Fig. 2-5).
- The highest number of companies answered that they needed five to ten years for technicians, integral to human resources for manufacturing, to become fully independent, which implies that the development of technicians with skilled techniques requires an extended amount of time (Fig. 2-6).
- As for ways to secure human resources for manufacturing, approximately 90% of companies answered that they employed and developed new graduates or mid-career workers by themselves, meaning that many companies develop human resources for manufacturing on their own (Fig. 2-7).

**[Fig. 2-5] Strengths of companies (multiple answers)**

- Having high-skill techniques: 33.8%
- Being capable of supporting extremely short turnaround times: 31.0%
- Being a major subcontractor for a blue-chip company: 24.1%
- Providing products or services that other companies find difficult to copy: 21.8%
- Dominating a small market: 18.4%
- Producing products that comply with international specifications: 13.1%
- Closely collaborating with multiple neighboring companies: 12.7%
- Continuing to invest in expensive equipment: 11.6%
- Having no obvious strengths: 9.0%
- Having acquired patents for multiple technologies and products: 7.9%
- Having extraordinary high technologies owned by the research and development department: 6.8%
- Providing products equivalent to earlier ones at lower prices: 6.6%
- Accounting for a large share in the global market for certain products or services: 5.7%
- Developing a group of superior companies as subcontractors: 4.5%
- Aggressively developing overseas factories: 4.3%
- Supplying machinery and parts for overseas manufacturers: 4.3%
- Other: 4.1%
- No response: 2.3%
- Outsourcing manufacturing as much as possible, emphasizing product planning: 1.8%

**[Fig. 2-6] Level and required years at which technicians are regarded as fully independent (“fully independent” means to have acquired the capability to independently deal with issues that may arise while they are on duty and to make schedules/preparations by themselves)**

- Level at which technicians are regarded as fully independent (%)
  - Being able to independently perform tasks without detailed directions if provided with preparations by their supervisors/seniors: 5.8%
  - Being able to schedule daily work on their own: 4.1%
  - Being able to independently deal with trouble that happens when they are on duty, in addition to the capability to make schedules/preparations by themselves: 1.8%
  - Being able to manage the most difficult work at workplaces such as launching new production lines: 1.6%
  - No technicians: 27.2%
  - No response: 60.3%

- The required years to become fully independent (%)
  - Less than 3 years: 18.3%
  - 3 or more but less than 5 years: 9.1%
  - 5 or more but less than 10 years: 28.6%
  - 10 or more but less than 15 years: 40.9%
  - 15 years or longer: 1.4%
  - No response: 1.7%

The skilled techniques possessed by human resources for manufacturing have become an important key for the industry to continue to grow as a field of good quality employment in the future. Thus, it is necessary to develop human resources for manufacturing, to improve their skills and capabilities, and to develop them into fully independent and skilled technicians in order to support companies and the quality employment opportunities they provide.

In addition, it is necessary to increase labor productivity through the development of human resources for manufacturing and provision of opportunities for them to improve their skills and capabilities.

YASDA PRECISION TOOLS K. K. manufactures numerically controlled machines equipped with automatic tool changers called machining centers. They are more expensive than the machines mass-produced by other companies, but the sliding surfaces of the parts that are the machines' bases are treated with a kind of special final metal processing (scraping) using the “skills of craftsmen” in a process for producing ultra-precision machine tools, which enables differentiation of the products by achieving ten times the precision of other products. As a result, the products are being delivered to manufacturers in various industries around the world in addition to those in Japan.

Scraping, the quality of which relies on experience acquired through years of work, is handed down to the next generation by having skilled workers and young workers perform tasks as a team. Young workers are supposed to observe the skilled workers and get direct experience in order to duplicate and inherit the techniques themselves.

The retirement age at YASDA PRECISION TOOLS is 60. Craftsmen, who have continued to develop their skills until retirement age, continue to be employed until age 65 as part-timers and play active roles as skilled workers and in mentoring positions for OJT.

Also, a strong human resource retention rate is due to each employee’s “pride” that they are “manufacturing the most precise things in the world” and “being engaged in state-of-the-art work” enables the transfer of skills through OJT like this.
3. Current status of development and retention of human resources in the manufacturing industry

A brief summary of the actual status of the development of human resources and their capabilities at companies for which human resources for manufacturing have played important roles:

- Regarding recruitment policies for human resources for manufacturing, the smaller the company size, the more likely they mostly hire at irregular intervals, and 61% of companies that answered that they mostly hire at regular intervals have hired human resources periodically for at least the last ten years. (Fig. 2-8).

- Regarding efforts made for the retention of human resources for manufacturing, the leading methods were reported as an “increase in wage levels” (49.1%) and the “treatment of employees according to their abilities” (44.5%), which indicates that various efforts such as improving the treatment of employees are being made (Fig. 2-9).

[Fig. 2-8] Recruitment status of human resources for manufacturing

[Fig. 2-9] Efforts to increase retention rates for human resources for manufacturing (multiple answers)

Regarding efforts to develop human resources for manufacturing, “supervisors or senior workers giving instructions during daily work” (88.1%), “considering employees' job duties and letting them experience these duties starting with easy work, then moving to difficult work” (52.8%), “working with standard operating procedures and operation manuals” (47.3%), “letting them experience related jobs in rotation in addition to the main jobs for which they are responsible” (35.6%), and other efforts are being implemented (Fig. 2-10).

78.4% of companies are making efforts to pass down skilled techniques, and among these companies, the “use of elderly workers through re-employment or employment extension” (48.7%) is the most common method, followed by “compilation of skills to hand down in texts and manuals” (25.8%) (Fig. 2-11).

The actual situations mentioned above show that the manufacturing industry is developing human resources in various ways, implementing improvements in the treatment of employees such as raising wages, and creating fields of good quality employment, although it takes time to develop these human resources.
Several issues regarding education and training for human resources for manufacturing are “no time for development” (43.5%), “cannot secure enough young human resources for manufacturing” (37.3%), and “there are not enough instructors” (35.8%) (Fig. 2-12).

As for support related to securing and developing human resources for manufacturing, most companies asked government for “activities to enhance young people’s interest in manufacturing” (43.1%), followed by an “expansion of eligibility for subsidies / increase in subsidies for business operators who implement vocational training” (34.7%) (Fig. 2-13).

**Fig. 2-12** Issues in implementing education and training for human resources for manufacturing (multiple answers)

- No time for development: 43.5%
- Not enough young human resources for manufacturing cannot be secured: 37.3%
- There are not enough instructors: 35.8%
- Persons who are instructed are deficient in ability and motivation: 25.3%
- Instructors are deficient in ability and motivation: 19.0%
- There is not enough communication between employees: 16.0%
- The budget to develop human resources is insufficient: 15.3%
- The skills to be handed down or transferred are not clear: 14.3%
- Proper ways for developing human resources are not understood: 13.5%
- The retention rate for human resources for manufacturing is low: 6.9%
- It is difficult to deal with technological innovation and frequent changes in tasks: 2.4%
- It is difficult to get information about external training institutions and vocational training courses: 1.2%

**Fig. 2-13** Government support related to securing and developing human resources for manufacturing (multiple answers)

- Activities to enhance young people’s interest in manufacturing: 43.1%
- Expansion of eligibility for subsidies / increase in subsidies for business operators who implement vocational training: 34.7%
- Provision of information related to enhanced education/training benefit system, and educational training institutions and support for personal development for employees: 24.4%
- Improvement of training for current employees who can be candidates for human resources for manufacturing: 23.7%
- Implementation of workshops to strengthen employees’ leadership: 21.5%
- Provision of information related to persons who have completed public vocational training: 21.3%
- Implementation of lecture sessions for young technicians led by skilled workers: 17.2%
- Preparation of customized vocational training courses corresponding to company needs: 15.7%
- Establishment of consultation and guidance services for the improvement of manufacturing sites: 12.4%
- Establishment and expansion of training courses supporting new technologies: 12.1%
- Support for compilation of information about processing and assembling technologies in databases and manuals: 9.9%
- Provision of information related to the status of the establishment of vocational training courses in communities: 8.3%
- Other: 4.1%

Therefore, the following efforts are needed:

(i) As support for securing human resources, the implementation of efforts for **collaboration with Polytechnic Colleges and other institutions**, **promoting the attractiveness of manufacturing by Monodzukuri Meisters (experts in manufacturing)**, **smooth matching including support for the professional choices for young people**, and the **development of human resources including skilled female workers through vocational training based on company needs**

(ii) As support for the development of human resources at companies, the implementation of the **improvement of subsidies for internal development of human resources**, **promotion of the proactive use of custom vocational training at Polytechnic Centers and other institutions**, **promotion of more people taking the National Trade Skill Test**, and other measures.

[Column] Securement of human resources through collaboration between three ministries (Hiroshima Skill Fair)

The 31st Hiroshima Skill Fair, which was held at the same time as the Hiroshima Manufacturing Festival 2014, is a yearly event aimed at broadly publicizing the significance and necessity of developing vocational abilities to people in Hiroshima Prefecture, as well as increasing student interest, primarily from elementary school to high school, in the manufacturing industry and in manufacturing careers.

Although Hiroshima Prefecture and the Japan Vocational Ability Development Association are the organizers, the Ministry of Health, Labour and Welfare (MHLW), METI, and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) collaborate directly and indirectly regarding the project cost burden, calls for associations and companies to participate, the gathering of participants, and other efforts.

The Skill Fair is held for two days, and elementary school and junior high school students can not only see demonstrations but also participate in the making things and experience the fun of manufacturing in various areas. Business operators convey the basic principle that manufacturing is synonymous with raising people, and appeal to the attractiveness of the manufacturing industry.

Photo: Demonstration of thin plate working

Photo: Manufacturing experience
In the manufacturing industry, which is a field of good quality employment, business performance is rising as human resources for manufacturing plays an active role; the manufacturing industry is becoming a field of good quality employment for human resources for manufacturing, and it is making progress in the development of human resources for manufacturing as business performance is improving. In this way, it is thought that these factors are mutually related, and that they are producing a virtuous cycle.

So, it is necessary to keep and expand the manufacturing industry, which is a field of a good quality employment, through various policies.

[Column] Realizing a virtuous cycle by actively involving women (NIPPON SEIKI CO., LTD.)

Although the manufacturing industry tends to be viewed as a workplace for men, the company president thought that including women, especially in certain job functions, would yield positive results, and began hiring and assigning them to the production management department. By increasing the number of perspectives, experiences, and knowledge bases, the team was able to better understand the production process through enhanced collaboration, thus enabling solutions to long-standing issues facing the company, in particular the problem of having excess inventory, generating a virtuous cycle of production and delivery on demand. And, they use their trademark, DOKURO (a skull, implying pirates), along with “Made in Japan” to label the engine valves they make and export overseas to express their passion for conveying the Japanese spirit of taking care of things and the superior technology of the parts.

[Column] Developing human resources through the use of an authorized in-house test system (SHIKOKU TOWEL INDUSTRIAL ASSOCIATION)

The SHIKOKU TOWEL INDUSTRIAL ASSOCIATION, which is located where Imabari towels are manufactured, could not secure and develop human resources, with the total number of its associate companies decreasing from 500 at its peak to one fifth of that amount, which resulted in the challenges associated with an aging workforce at production sites. Therefore, the company implemented the SHIKOKU TOWEL INDUSTRIAL ASSOCIATION in-house skill test according to the authorized test system of the Ministry of Health, Labour and Welfare in 2011, passed down skills, and secured and developed young human resources. In addition, the company appoints persons who have mastered the best technologies and skills as Towel Meisters, and now five Towel Meisters from 65 to 72 years old instruct young workers.

5. Future directions for Fostering and Securing Human Resources in the manufacturing industry, which is a field of good quality employment

- In the manufacturing industry, which is a field of good quality employment, business performance is rising as human resources for manufacturing plays an active role; the manufacturing industry is becoming a field of good quality employment for human resources for manufacturing, and it is making progress in the development of human resources for manufacturing as business performance is improving. In this way, it is thought that these factors are mutually related, and that they are producing a virtuous cycle.
- So, it is necessary to keep and expand the manufacturing industry, which is a field of a good quality employment, through various policies.
### Section 2. Efforts to Develop Human Resources for Manufacturing Who Support Good Quality Employment

#### 1. For More Effective Training for Manufacturing

(i) Implementation of training for manufacturing in response to training needs

In order to implement vocational training that better responds to the needs of industry, various efforts are being made such as promoting collaboration and cooperation between employers’ organizations and Polytechnic Centers through vocational training and developing curricula for vocational training in response to the needs of local communities.

(ii) Implementation of vocational training to master the skills required at manufacturing sites

Curricula for training in the fields of environmental technology and energy, which are expected to grow, are being developed so that people can master the abilities required at manufacturing sites, and training to enhance skills for vocational training instructors is being conducted so that instructors can do their jobs based on advanced technologies and skills.

(iii) Effective review of fields of training in response to the needs of industries and regions

The Polytechnic University conducts surveys to ascertain companies’ human resource needs. Based on the survey results, training curricula for the Polytechnic Centers and Polytechnic Colleges are being reviewed.

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**[Column] Development of technicians for aircraft production**

The Chubu region is home to the largest aerospace industry cluster in Japan, which accounts for approximately 50% of the production of aircraft parts in Japan; in particular, Aichi prefecture has been designated as the Special Zone to Create Asia’s No. 1 Aerospace Industrial Cluster in the Global Strategic Comprehensive Zone, and is proceeding with the production of next-generation medium-sized jet airplanes and the development of the first domestic jetliners in Japan. The manufacturing of aircraft parts inherently requires extremely high reliability and strict quality assurance, and the development and securement of technicians capable of meeting manufacturing standards are urgent issues.

In response, the Chubu Polytechnic Center organized a consortium, working with related institutions including Aichi Prefecture, the Aichi Labour Bureau, the Chubu Bureau of Economy, Trade and Industry, the Chubu Aerospace Technology Center, and the Chubu Association of Vocational Schools to develop training curricula for technicians in the manufacture of aircraft, and is providing training by subcontracting to private educational training institutions in Aichi.

This training features wide-ranging study of basic knowledge related to the manufacture of aircraft, basic skills related to the general structural assembly of aircraft airframes, and the general foundations for being an upstanding member of society, particularly as it related to individuals and organizations engaged in the aircraft industry. Industries and administrative agencies in the Chubu region are anticipating that it will constitute and contribute to new specialized training to develop technicians for aircraft manufacturing.

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<table>
<thead>
<tr>
<th>Application period</th>
<th>Training period (three months)</th>
<th>Course fee</th>
<th>Textbook fee</th>
<th>Entrance exam date</th>
</tr>
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<tr>
<td>From January 5, 2015 (Mon.) through February 28, 2015 (Wed.)</td>
<td>From March 19, 2015 (Thu.) through June 18, 2015 (Thu.)</td>
<td>Free (loan system)</td>
<td>Free</td>
<td>February 4, 2015 (Mon.)</td>
</tr>
</tbody>
</table>

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*The fee for working wear needs to be paid by trainees.*

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**Contact information**

- **Japan Organization for Employment of the Elderly, Persons with Disabilities and Job Seekers**
  - Phone: 052-21-654

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*Photo: A brochure for a training course based on the developed curricula*
2. To Improve Private Sector Vocational Training

(i) Subsidies for private companies for voluntary vocational training
   The Career Development Promotion Subsidy and the Subsidy for Career Upgrading are granted to support the development of human resources inside companies by employers.

(ii) Accredited vocational training by employers’ organizations
   Assistance is provided to owners of SMEs that conduct accredited vocational training to meet specific standards by the competent prefectural governor.

(iii) Improvement of training quality
   In December 2011, the Guidelines for Vocational Training Services at Private Educational Training Institutions were established to improve the quality of private educational training institutions. Efforts are being made to ensure that the guidelines are widely known and understood.

3. Creation of a Socially Acceptable Ability Evaluation System

(i) National Trade Skill Test System
   The National Trade Skill Test System (the national test system to evaluate and authenticate the skills of workers based on certain criteria administered by the Minister of Health, Labour and Welfare) plays an important role in encouraging workers, including manufacturing workers, to acquire skills and enhances their position in society (skill tests are available for 128 job categories as of April 1, 2015, and there are now approximately 5.47 million Certified Skilled Workers).

(ii) Vocational Ability Evaluation Standards
   Based on an analysis of detailed industry surveys, the Vocational Ability Evaluation Standards were established by compiling and systematizing the vocational abilities and knowledge necessary to perform the duties of personnel of all levels, from rank-and-file workers to superintendents responsible for an organization or department. These standards are intended to create an ability-oriented labor market for 52 areas of business, including the manufacture of electrical machinery and equipment.
4. Measures to Cope with the Reluctance of Young People to Engage in Manufacturing

(i) Training for high school graduates by Polytechnic Colleges, etc.
   - Polytechnic Colleges and other educational institutions nationwide provide manufacturing training for high school graduates and other job seekers.
   - They collaborate with industrial high schools and other institutions by dispatching vocational training instructors and other staff.

(ii) Transfer of skills to young people and communicating the attractiveness of manufacturing
   - Skilled workers with high-level manufacturing skills are certified as Monodzukuri Meisters (experts in manufacturing) and dispatched to companies and other entities to provide practical training (Monodzukuri Meister (experts in manufacturing) System).
   - Since FY 2014, Monodzukuri Meisters have also been dispatched to elementary schools and junior high schools to demonstrate manufacturing processes.

(iii) Communicating the attractiveness of manufacturing
   Through awards for outstanding skilled workers and various competitions (the National Skills Competition, Worldskills Competition, and National Vocational Skills Contest for the Disabled Persons (Abilympics) ), efforts have been made to widely foster a skill-oriented mindset in society.

(iv) Regional Youth Support Stations
   NPOs and other organizations have established and are operating Regional Youth Support Stations to provide employment support (such as consultations with career consultants and provision of work experience) to so-called NEETs and other young people.

The Monodzukuri Meister System

Skilled workers are certified and registered as Monodzukuri Meisters (experts in manufacturing), and then dispatched to SMEs, schools, and other institutions. There, they provide practical coaching on skills for young technicians and demonstrate the attractiveness of a manufacturing career. (There were 5,564 certified people as of the end of FY 2014.)

[Column] Efforts to give opportunities for manufacturing experience at Regional Youth Support Stations

According to the idea that manufacturing is the basis for various skills, the Eastern Shizuoka Youth Support Station is aggressively making efforts for the provision of opportunities for work experience. There is an office producing parts related to automobiles in the headquarters of the Eastern Shizuoka Youth Support Station, and it teaches the ABCs of manufacturing through workplace experience.

In FY 2014, the Station adopted the Monodzukuri Meister System and supported people in learn the basics of tiling and pattern making in and enjoyable atmosphere. Many young people became interested in manufacturing by seeing and experiencing it firsthand, something they can not often appreciate in daily life. Consequently, 60 out of 160 unemployed young people (38%) obtained manufacturing related jobs in FY 2014.

The Center will continue to place importance on providing manufacturing experience and support unemployed young people in obtaining jobs.
Communication of the attractiveness of manufacturing to women

The government decided to provide women with opportunities to attend open campus events and hear about the personal experiences of female trainees, and set up a web site for women in FY 2014.

Promotion of the employment of women in manufacturing

The government is also implementing support measures for ability development for women depending on their life stage, by, for example, developing and providing manufacturing-related courses for women and improving daycare nursery services during vocational training to enable women to find jobs in the manufacturing industry.

Financial aid for employers

In order to support employers who are planning to promote the success of women, the government established an upskilling course for persons who are on childcare leave and or have returned to work through the Subsidy for Promoting Career Formation. From FY 2015, the Subsidy for Upgrading Careers is to also include new financial aid for implementation of training for persons who are on childcare leave, in addition to the expansion of subsidy eligibility rates.

5. Support for Fostering Skilled Female Workers

(i) Communication of the attractiveness of manufacturing to women

The government decided to provide women with opportunities to attend open campus events and hear about the personal experiences of female trainees, and set up a web site for women in FY 2014.

(ii) Promotion of the employment of women in manufacturing

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[Column] National Skills Competition (interview with the winner of the 52nd National Skills Competition)

Working on sheet-metal processing for automobiles: Mr. Takuma Shimizu (TOYOTA MOTOR CORPORATION)

[What motivated you to work hard and participate in the competition?]

I was hoping to be like a more experienced co-worker who had participated in the Competition, and I thought I'd like the challenge too.

[What did you do and how much time did you spend training for the competition?]

Throughout the year, I repeatedly practiced the skills needed to manage the tasks in the Competition. After the task was announced, I did exercises to conquer my weaknesses and repeated test runs to measure my time under conditions that simulated the Competition.

[What were the rewarding and difficult parts of the process leading up to the Competition?]

(Rewarding part) The time when I was able to create the products as I had imagined them.

(Difficult part) The time when I couldn't create the products for a long time although I understood them in my mind.

[What parts of your participation in the Competition were meaningful?]

Competing and building bonds with persons of a similar age who have the same goals as me.

[How do you intend to leverage your experience in winning the competition in the future?]

I will get the best from my “spirit, technique, and physical strength,” acquired through the National Skills Competition, and contribute to my workplace. And, I will hand down my passion and skills to my less experienced co-workers who aim to compete in the National Skills Competition.

[Because of your victory at the Competition, you were selected as a representative of Japan in the 43rd World Skills Competition to be held in Sao Paulo, Brazil in August 2015, so please tell us about your enthusiasm for this new challenge.]

I will show the world advanced skills from Japan and definitely win the championships for three years in a row!
(i) Career consultations
A system to promote career consultations is being developed to enable individuals to make their own vocational life plans in accordance with their competences and experience, and to select jobs or receive training to develop their vocational abilities in an effective manner.

(ii) Utilization of the Job-Card system
Efforts are being made to further promote the Job-Card system to provide practical vocational training by combining internships and classroom lectures to help participants find stable employment.
Scientific and technological innovation is an important pillar of the growth strategy of Japan, and the development of human resources that support this is an important key for manufacturing. In particular, it is important to develop and secure creative young researchers and to develop human resources who can play active roles in various fields and human resources in science and technology who will be responsible for the next generation. In order to develop and secure creative young researchers, the environment is to be improved to enable researchers to concentrate on research, and financial support is to be provided for young researchers. In addition, collaborating with companies and establishing a consortium with multiple universities, the government is to implement the Project for Establishing a Consortium for the Development of Human Resources in Science and Technology to promote the securement of stable employment for researchers, career development, and the diversification of career paths.

As for the development of human resources who can play active roles in various fields, responding to the situation where the success of doctoral degree recipients is insufficiently promoted in Japan (Fig. 3-1), the government is making efforts to promote the diversification of the career paths of doctoral degree recipients. And the government is also providing support for universities that are implementing the development of practical human resources who will become entrepreneurs or lead innovation, collaborating with private companies and overseas institutions.

As for the development of human resources who will be responsible for the next generation, in order to increase the number of children who choose science and mathematics and develop those abilities, the government is planning for the enhancement of science and mathematics education such as by designating Super Science High Schools and hosting the Japanese competitions for the International Science Olympiad and national championships including the Science Koshien.
In order to create scientific and technological innovation that leads to new value and technological innovation in manufacturing, strengthening the fields of science and technology has become more necessary than ever before. In order to proceed with efforts for the strategic development of human resources in science and technology through collaboration between industry, academia, and government, in March 2015, the government established and released the Strategy for Development of Human Resources in Science and Technology, which summarizes the three directions and 10 priorities on which the government should focus and make progress by the end of FY 2020. And in order to make efforts for the qualitative enhancement and quantitative securement of human resources in science and technology through collaboration between industry, academia, and government, the government established the Industry-Academia-Government Round-Table Council on Fostering Human Resources in Science and Technology (Fig. 3-2, Fig. 3-3).

2. Strategy for Development of Human Resources in Science and Technology

In order to proceed with efforts for the strategic development of human resources in science and technology through collaboration between industry, academia, and government, in March 2015, the government established and released the Strategy for Development of Human Resources in Science and Technology, which summarizes the three directions and 10 priorities on which the government should focus and make progress by the end of FY 2020. And in order to make efforts for the qualitative enhancement and quantitative securement of human resources in science and technology through collaboration between industry, academia, and government, the government established the Industry-Academia-Government Round-Table Council on Fostering Human Resources in Science and Technology (Fig. 3-2, Fig. 3-3).

- [Direction of the Strategy: 1] Strengthening educational research functions at higher education phases
  - Priority 1. Strengthening the system for the development of human resources who will become professionals and leaders in science and technology
    - Based on commitments by industry, construct a vocational education system at the level of higher education through practical problem-solving education methods, and strengthen these functions drastically to develop professionals in science and technology. In order to develop leaders who will play active roles globally across industry, academia, and government, promote the strengthening and fundamental reform of education for doctoral courses such as by gathering top-class domestic and overseas teachers from industry, academia and government and constructing systematic education beyond the frames of specialized fields.
  - Priority 2. Promoting the globalization of the functions of educational institutions
    - Promote the globalization of the educational functions of universities and other institutions, and develop human resources in science and technology who can discover and solve issues on a global scale. Promote the establishment of study abroad programs and credit-transfer with overseas universities for curricula in the fields of science and technology.
  - Priority 3. Creating continuous and progressive innovation by collaborating with local companies
  - Priority 4. Develop human resources in science and technology through the development and reorganization of education and research organizations at national universities

- [Direction of the Strategy: 2] Providing children with experience and young people, women and adults with growth opportunities
  - Priority 5. Cultivating creativity, inquiring minds, independence, and a spirit of entrepreneurship in primary and secondary education
    - In order to promote proactive and collaborative learning (Active Learning), systematically promote efforts to develop educational conditions and an environment for observation and experimentation and to discover and develop students who have motivation and ability by collaborating with universities.
  - Priority 6. Developing the venture spirit in students and young researchers
    - Promote the development and implementation of programs for the development of human resources at universities to acquire the venture spirit and the mind of an entrepreneur, and develop human resources who are willing to be involved in the venture industry starting in universities or who will start new businesses.
  - Priority 7. Promoting the advancement of women in the fields of science and technology
  - Priority 8. Promoting the success of young researchers
  - Priority 9. Promoting the acquisition of knowledge and technologies in various advanced fields by industrial human resources – Promoting retraining for adults –

- [Direction of the Strategy: 3] Dialogue and collaboration between industry, academia, and government
  - Priority 10. Establishing the Industry-Academia-Government Round-Table Council on Fostering Human Resources in Science and Technology (tentative name)
    - In order to strategically develop human resources in science and technology who play active roles especially in industry, establish the Industry-Academia-Government Round Table Council on Fostering Human Resources in Science and Technology (tentative name) in which industry, academia, and government will share information and knowledge related to human resources in science and technology, and collaborate in matters such as support in fields where expectations for the development of human resources are high.

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**International comparison of entrepreneurial activity**

<table>
<thead>
<tr>
<th>Total Early-stage Entrepreneurial Activity Index</th>
<th>[Total Early-stage Entrepreneurial Activity]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of persons responding to a questionnaire that they are entrepreneurs or planning to launch a business (%)</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Research on entrepreneurship (GEM), FY 2012 (Major countries of the OECD appeared among surveyed countries; the latest numbers are used among those from 2011 and 2012)
As for efforts made at each type of school, universities (engineering schools) are to implement practical engineering education in collaboration with industry including experiential classes and seminars featuring group work and the development of human resources in science and technology in response to globalization such as through programs for engineering English and exchange programs in collaboration with overseas universities. And, in order to develop highly-skilled professionals, consider the creation of new institutional systems of higher education that conduct practical vocational education.

Colleges of technology are to introduce model core curricula for the securement of the quality of education and to strengthen efforts such as the implementation of specialized education in English in order to develop engineers who can play active roles. Additionally, national colleges of technology are to start efforts to develop robotics engineers who can solve various social issues as one type of the education in new fields and areas in response to the needs of regions and industry.

[Efforts at a university – Kanazawa Institute of Technology –]
The Kanazawa Institute of Technology and Kanazawa Technical College have become members of CDIO, in which more than 100 universities and institutions of higher education around the world including the Massachusetts Institute of Technology (MIT) participate and which is an international framework for the enhancement of the quality of education for engineers, and are attempting to improve their education.

CDIO places emphasis on learning experiences in which one simultaneously acquires skills for managing individual and interpersonal relationships and skills for developing products and systems, for example, learning about the design of products and associated social responsibilities by designing such products through one learning experience. CDIO also tries to improve the environment in work spaces that enable students to learn, discuss, produce things, and experiment. The Kanazawa Institute of Technology is providing project design education, in which students try to understand users’ real needs as a team, realize their own solutions, and experiment with, verify, and evaluate them, as a mandatory course.

*The name CDIO is an acronym for Conceive, Design, Implement and Operate.

[Efforts at colleges of technology – Competition of Ideas – Robot Contest of the National Colleges of Technology –]
The Competition of Ideas – Robot Contest of the National Colleges of Technology – is held every year as an educational event in which students of colleges of technology nationwide freely and independently design and build robots under annually changing rules, thereby cultivating originality and a shared interest in manufacturing. Japan’s Robot Strategy compiled by the Robot Revolution Realization Council in January 2015 emphasizes technological innovation through robots, and not only the government but also industry are focusing on the Contest, in which students of colleges of technology who are future engineers who will support the future of Japan compete with their own fresh ideas.

In the 27th Contest in FY 2014, in a competition for “prompt delivery service,” students competed in “delivery service” using robots. Around 4,000 people visited the Ryogoku Kokugikan to cheer on the heated competition among students with highly original robots incorporating the advanced technology that they learned about in school.

[Scene from the Competition: the champion robot awarded the grand prize, “Maji no Takuai-bin (Serious delivery service)” (National Institute of Technology, Kumamoto College)]
Among specialized upper secondary schools, Super Professional High Schools (SPH), which are designated as specialized upper secondary schools that make advanced efforts and also conduct survey research, have been started, aiming to develop professionals who respond to changes in society and trends in industries, master advanced knowledge and skills, and can play active roles in the front ranks of society. Specialized upper secondary schools are making efforts to plan to develop entrepreneurship in students aiming to launch businesses and to manage companies by having students experience the process from development through sales of products in collaboration with local companies.

Specialized training colleges have organized an industry-academia-government consortium that promotes the development of a new learning system in order to promote the strategic development of core professionals, responding to the needs of industry. And, the Minister of Education, Culture, Sports, Science and Technology has certified and is promoting vocational and Professional Post-secondary Course that provide practical vocational training in close collaboration with companies in education programs at specialized training colleges.

[Efforts at specialized upper secondary schools – efforts in Iwate prefecture –]

In 2014, the offices of the Miyako-Shimohei Monodzukuri Network Industry Working Group conducted efforts to develop superior future young female engineers by giving opportunities for work experience to female high school students. They designated "making the school badges of the school that the students belong to" as the goal of the exercises, and first-class machine processing technicians who were workers at companies providing work experience and female engineers who had graduated from the engineering colleges of local universities (all from Miyako City) served as instructors. Students who participated in the exercises could understand the relationship between learning at school and the real world more clearly through the work experience, and their attitudes toward learning in class and the results of that learning improved dramatically. In addition, the work experience has helped increase their motivation to take initiative in building their future as well as to make classes livelier. The accumulation of these experiences is expected to lead to the formation of a local community in Miyako and Shimohei where women truly shine.

[Efforts to develop core specialized human resources at a specialized training college – Nippon Engineering College of Hachioji –]

In FY 2012, the College accepted a commission for a project for the “strategic promotion of the development of core professionals in growing fields” from MEXT. The College established a consortium with industry, academia, and government, and has made efforts for the development of national model curricula in the field of infrastructure (civil engineering and construction), for which an increase in the demand for human resources is expected due to the redevelopment of social infrastructure toward holding the Tokyo Olympics. In FY 2014, which was the third year of the project, the College completed the national model curricula and syllabi and developed model courses in which students could study under part of the model curricula in order to respond to the need for retraining adults. And, in order to make the national model curricula adapt to regional features, the College implemented three types of demonstration courses for learning about advanced technologies as well as qualifications and work in the construction industry for young workers at construction companies and persons who hope to be engaged in construction work in the Tama (Hachioji) area, which has varied infrastructure including the National Capital Region Central Loop Road and Tama New Town, to promote the development of human resources in the area. In the future, the College plans to spread its developed curricula, adapting to regional features and strengthening collaboration with regions and companies.
● Promoting the success of female researchers and bringing out their abilities are very important for the recovery and vitalization of Japan’s economy.

● Although the ratio of female researchers has increased annually, it was approximately 15% as of March 2015, and it remains at a low level compared with other countries (Fig. 3-4, Fig. 3-5).

[Fig. 3-4] Ratio of female researchers to the total number of researchers in Japan

[Fig. 3-5] International comparison of ratios of female researchers

● To assist female researchers, in response to the review by the Task Force for Promoting Research Done by Women, which was established by MEXT, in FY 2015, the Initiative for the Realization of Diversity of Research Environments was started, and focused support has been implemented for universities and other institutions that promote the balancing of the research activities and family lives of researchers such as the responsibilities of child bearing, child rearing, and providing care to elderly family members and that increase the ability of female researchers to conduct research in an integrated manner.

● As for assistance for women in scientific fields, the Japan Science and Technology Agency provides a program encouraging female lower and upper secondary school students to take science courses by providing them with opportunities to interact with prominent female researchers and university students in scientific fields, offering them lab classes, and having them attend lectures.

● These efforts encourage lower and upper secondary school students to take science courses and promote the development of more female researchers who play active roles in the field of natural science.

[Experience with a solar battery. Adding electrolytes with a pipette (Osaka Prefecture University)]
In order to develop future human resources for manufacturing, it is important to develop job consciousness through the provision of working experience related to future careers for young people, etc. Therefore, various efforts have been made to develop career and vocational education through each type of school, including the promotion of internship programs from the elementary and secondary education levels as a part of career education, the development of a system which helps students be socially and vocationally independent at the higher education level, and the promotion of the development of core professionals in growing fields in collaboration with industry and educational institutions including professional training colleges. Additionally, universities and other institutions are working with industry to assist in the re-training of young people.

In order to deepen the understanding of ordinary citizens and young people in terms of both the fun and importance of manufacturing, the National Museum of Emerging Science and Innovation (Miraikan) has been producing exhibits that introduce advanced science and technology with easy-to-understand explanation, holding related events, and trying to provide opportunities for researchers and the public to communicate. Additionally, public educational facilities including community centers and museums have been holding workshops in which parents, children, and the elderly make something together and conducting activities to support learning to enhance children’s interest in manufacturing and to breathe life into local communities.

The government has been endeavoring to transmit manufacturing traditions to future generations by fostering successors for important intangible cultural properties, protecting selected conservation techniques, and taking other measures.

[Factory visits and manufacturing experiences in industry classes – Ehime Prefectural Science Museum –]

The Ehime Prefectural Science Museum holds approximately 40 classes every year. Among these, in classes related to industrial fields, visits to actual industrial sites and experiences in manufacturing are provided to help students learn about the industrial history of Ehime. During factory visits in FY 2014, called Chemical Factory Visits, participants visited the Ehime works of Sumitomo Chemical Co., Ltd. in the city. Attendees enjoyed participating in informative and lively Q&A sessions with workers -- proof of the success of the program.

In the manufacturing experiences, called the “Challenge to make Tobe ware by kneading clay! – Mission to complete summer vacation homework,” workshops for making Tobe ware, which is a traditional industry in Ehime, were held. Participants learned about the history of Tobe ware, then, actually kneaded clay, completed some Tobe ware on their own, and experienced both the difficulty and enjoyment of the process.

[A project to demonstrate selected preservation techniques in FY 2014 “Japanese Techniques Experience Fair – Let’s experience craftsmen’s techniques which have continued to preserve cultural property!”]

At an event called “Japanese Techniques Experience Fair – Let’s experience craftsmen’s techniques which have continued to preserve cultural property!,” run under a project to demonstrate selected preservation techniques, each of 31 organizations that preserve selected preservation techniques including the Association of Engineers for Conservation of Cultural Property Gardens set up a booth, exhibited panels introducing the activities of the organizations and aspects of the production processes such as the materials used in an easy-to-understand manner, exhibited the materials and tools used in traditional repairs, and set up experience corners for activities including roofing and the making of personalized chopsticks, hand brooms, and coasters using traditional patterns (like lattices).

Many people visited the exhibitions, demonstrations, and experience booths; in particular, the experience booths were popular among children, and they obviously enjoyed their experiences.

[Experience making a hand broom — Association of Engineers for Conservation of Cultural Property Garden]
Section 3. Promotion of Research and Development to Enhance Industrial Strength

1. Research and development in fundamental core manufacturing industry technologies

- Toward strengthening the industrial competitiveness of Japan, it is necessary to establish a common infrastructure for new manufacturing technologies in order to meet the needs of various markets. Therefore, research and development is to be promoted in fundamental areas common to many industries and having strong ripple effects through research and development for the most advanced measurement and analysis techniques/equipment and the development and shared use of large-scale research and development infrastructure.
- Cutting-edge measurement and analysis techniques are key technologies essential to the development of science and technology, and efforts have been made to strengthen research and development infrastructure by promoting collaboration between industry, academia, and government.

Hayabusa2 – asteroid explorer which is filled with Japanese monodzukuri technologies –

The asteroid explorer Hayabusa2 was launched aboard the H-IIA launch vehicle No. 26 from the Tanegashima Space Center in Kagoshima Prefecture in December 2014 as the successor to Hayabusa, which was the first spacecraft to bring back samples from the asteroid Itokawa and drew international attention.

At present, Hayabusa2 continues to travel in space toward the asteroid 1999 JU3, which is its target for exploration.

1999 JU3 is called a C-type asteroid, is a primordial body even compared to stony asteroids, and is thought to contain more organic material and hydrated minerals than Itokawa, which Hayabusa explored.

Acquiring these organic samples and bringing back them to the Earth at the end of 2020 is the mission of Hayabusa2.

Hayabusa2 has more advanced technologies than Hayabusa in many ways. For example, Hayabusa2 has a new device which can create a crater by shooting a copper lump at the asteroid (collision device) to acquire sub-surface stone or sand containing organic matter that is unaffected by solar heat or other factors.

As for the collision device, although the method for accelerating the impactor to a high speed presented a very difficult technological problem, it was solved by using explosives for acceleration. It also became possible to load large amounts of explosives, secure the airtightness of the device, and, in addition, reduce its weight.

As for the ion engines used in Hayabusa their lifetime was improved, and their propulsion power was increased by 25% for Hayabusa2.

More than 100 companies from large manufacturers to small factories have been engaged in the development of the body and the devices installed in Hayabusa2, and Hayabusa2 represents a concentration of Japanese manufacturing technologies.

(Information provided by: Japan Aerospace Exploration Agency (JAXA))
As for nanotechnology and materials science and technology, the development of technology from fundamental and leading research for commercialization has been promoted strategically. Various research and development activities have been conducted including fundamental research and development to create new substances and materials and research and development for superalloys, fluorescent materials for white LED lighting, and next-generation solar battery materials to solve problems common to all humans such as issues surrounding the environment, energy, and resources.

MEXT is promoting the development of artificial intelligence, which is a fundamental technology for realizing cooperation between humans and robots, based on the pillar of the “fundamental enhancement of Japan’s robot-creation ability so as to make Japan the robot innovation hub of the world,” one of the three pillars of the New Robot Strategy. And for the “development of next-generation human resources,” MEXT considers interdisciplinary curricula related to the IoT (Internet of Things) at research institutions and universities, implements various projects, and also provides development for human resources attempting to start businesses.

As for post-K development, a project has been launched to develop the world’s top supercomputer and applications that contribute to resolving issues collaboratively (FLAGSHIP 2020 Project) with a target date set by the government for 2020.

[The supercomputer “K Computer” (Kobe city, Hyogo prefecture)]
(Information provided by: RIKEN)

[Fig. 3-6 Analysis of high speed driving stability when meandering] (Information provided by: Hiroshima University, Hokkaido University, Mazda Motor Corporation)

[Sharing research infrastructure and making the infrastructure into a platform]
As a project to promote the sharing of advanced research facilities and equipment that research institutions (including universities and incorporated administrative agencies) co-own with a broad range of users from industry, academia, and government, MEXT has implemented a project to form a platform of advanced research infrastructure to share, in response to the various needs of users and also has implemented the Nanotechnology Platform project in the nanotechnology field, which depends heavily on research devices.

Kyushu University, which is one of the institutions selected for the Molecule and Material Synthesis Platform, has promoted support for the synthesis of organic, inorganic, and inorganic-organic composite materials, as well as the construction and functional analysis of nanostructures in response to requests from external researchers from industry, academia, and government, using the most advanced research facilities with experience in the synthesis of molecules and substances and the construction of nanostructures.

A typical example of support is the case where Toray Industries, Inc. used these facilities in FY 2012 for the “development of film formation technology for CNT composite structures.” Toray considerably enhanced the dispersibility of double-walled carbon nanotubes, which enabled them to even be coated onto films, and Toray was successful in using the resulting films as conductive films. The analytical methods for quantifying the dispersibility of CNT dispersed in liquid that was developed using various facilities owned by Kyushu University contributed greatly to the realization of the outcome, and after that, Toray succeeded in its development and realized its commercialization as transparent conductive CNT films for electronic paper. In addition, now, cooperative research between them is developing, and this has become a model case as an example of collaboration between industry, academia, and government, which is the goal of the nanotechnology platform.

[Electronic paper using conductive film]
2. Promotion of research and development based on collaboration between the government, industry, and academia

- The establishment of effective cooperative relationships between universities that are knowledge hubs and companies contributes to the streamlining of manufacturing in Japan and increases in added value. Activities conducted in collaboration between industry, academia, and government at universities have shown upward trends since 2010 (Fig. 3-7).
- As for joint research between industry and universities, in order to develop human resources who will become entrepreneurs and create innovation, and based on the fact that there are fewer bases for collaboration between industry and universities compared with overseas, support for young researchers and graduate students in collaboration with private companies or overseas institutions for the creation of ventures originating in universities (Program for Creating Start-ups from Advanced Research and Technology) and the development of advanced human resources that study entrepreneurship and business creation (Enhancing Development of Global Entrepreneur Program) have been implemented.

[Fig. 3-7 Activities conducted in collaboration between industry, academia, and government at universities, etc.]

[Long-term Research and Development through Collaboration between Industry, Academia, and Government that Contributes to Progress in Saving Energy – the 2014 Nobel Prize in Physics –]

In 2014, Mr. Isamu Akasaki, University Tenured Professor at Meijo University (Nagoya University Lectureship), Mr. Hiroshi Amano, Professor at Nagoya University, and Mr. Shuji Nakamura, Professor at University of California, Santa Barbara were awarded the Nobel Prize in physics. They were awarded the Nobel Prize for the highly-acclaimed invention of efficient blue light-emitting diodes, which has enabled the manufacture of bright and energy-saving white light sources and their invention has had an enormous impact on society in easing the burden on the global environment through the proliferation of LED lighting, which is long-lasting and energy-efficient.

Professor Akasaki’s contribution to the research is a good example of how research and development has been promoted in collaboration between industry, academia, and government for a long time.

Professor Akasaki accumulated research, receiving the support of Grants-in-Aid for Scientific Research, and created high-quality single crystals of gallium nitride (GaN) in 1985 with Professor Amano, who was a student at that time.

After that, Toyota Gosei Co., Ltd. aimed to commercialize gallium nitride blue light-emitting diodes based on the results of Professor Akasaki’s research, using the Commissioned Development system of the Research Development Corp. of Japan (currently Japan Science and Technology Agency) from 1987 to 1990, and succeeded in 1995. In starting research and development, staff from the Agency, who noticed Professor Akasaki’s research in an official journal of a scientific society, visited his laboratory, and an employee of the company who listened to his lecture made him an offer to commercialize the results of his research. Consequently, they made it possible to match the seeds from a university with the needs of a company for development. As a project under the Commissioned Development system, Manufacturing technology of GaN blue light emitting diodes has brought the nation approximately 5.6 billion yen as income in royalties. These are good examples of how the enthusiasm of a company and the long-term support of public funds through research phases from basic research to commercialization produced success.

[Blue light-emitting diode]
As the promotion of science and technology in various regions can contribute to vitalizing local industry and improving the quality of life for local residents, it is necessary to actively drive such promotion. MEXT, METI, MAFF, and MIC jointly select Regional Innovation Strategy Promotion Regions for superior initiatives conducted through collaboration between regional industry, academia, government, and financial institutions toward the creation of regional innovation.

MEXT implements Regional Innovation Strategy Support Programs, which support efforts focusing on the concentration of researchers, the formation of intellectual assets, and the development of human resources in regions where MEXT's assistance is expected to contribute greatly to the realization of regional innovation strategies (Fig. 3-8).

[Fig. 3-8: Regions Receiving Support Through Regional Innovation Strategy Support Programs (as of July 1, 2014)]
Regional Innovation Strategy Support Programs
MEXT has implemented support that focuses on intangible and human assets, such as the formation of intellectual assets and development of human resources, for 37 regions that are expected to contribute considerably to the realization of scientific and technological innovation strategies in regions through the program.

The Yamagata Organic Electronics Innovation Strategy Promotion Area invites outstanding engineers (innovators), works on demonstrations and technology development for the core technologies for process innovation (device manufacturing technology through printing technology) jointly with companies inside and outside of the prefecture, and aims to have “Yamagata” become synonymous with organic electronics through industry-academia-government collaboration by using the program, in order to promote further development of organic electronics (organic EL devices, organic solar cells, organic transistors) technology including organic electro-luminescent lighting, known as the “strength of Yamagata,” and regional industrialization.

Through these efforts centering on organic electro-luminescent lighting, light, thin, and flexible circuits and organic electronic products such as light-emitting devices are starting to be produced, and the buildup of organic electronics-related businesses is progressing.

As mentioned above, Regional Innovation Strategy Support Programs contribute to the establishment of innovation regional ecosystems and will continue to strengthen industrial competitiveness and create new businesses and employment through regional innovation in the future.